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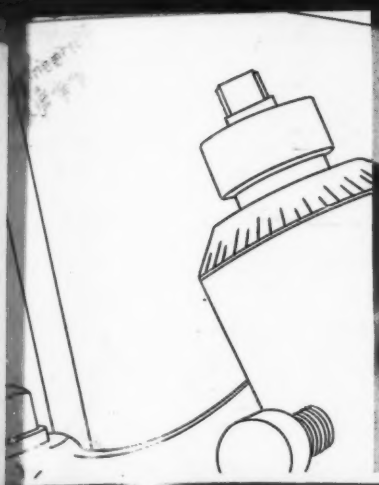
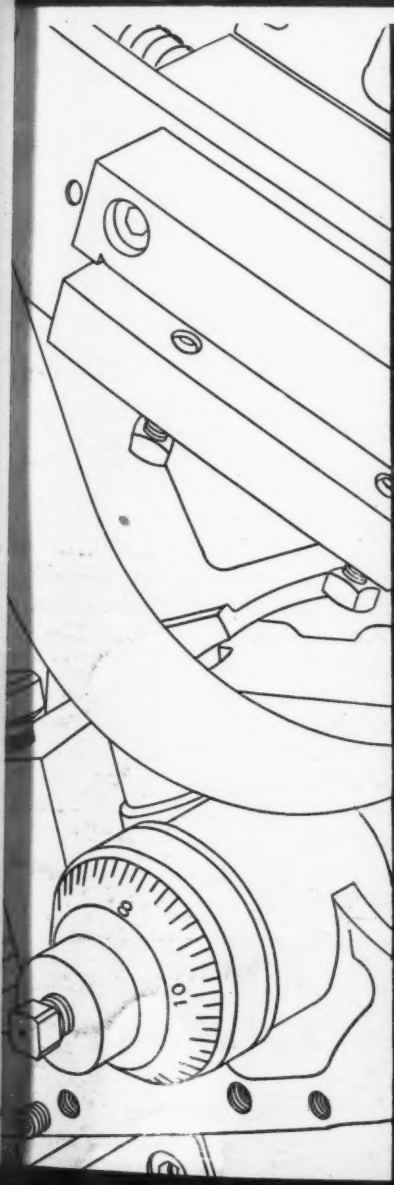


MACHINE DESIGN

January 1943



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Anatomy of Maintenance

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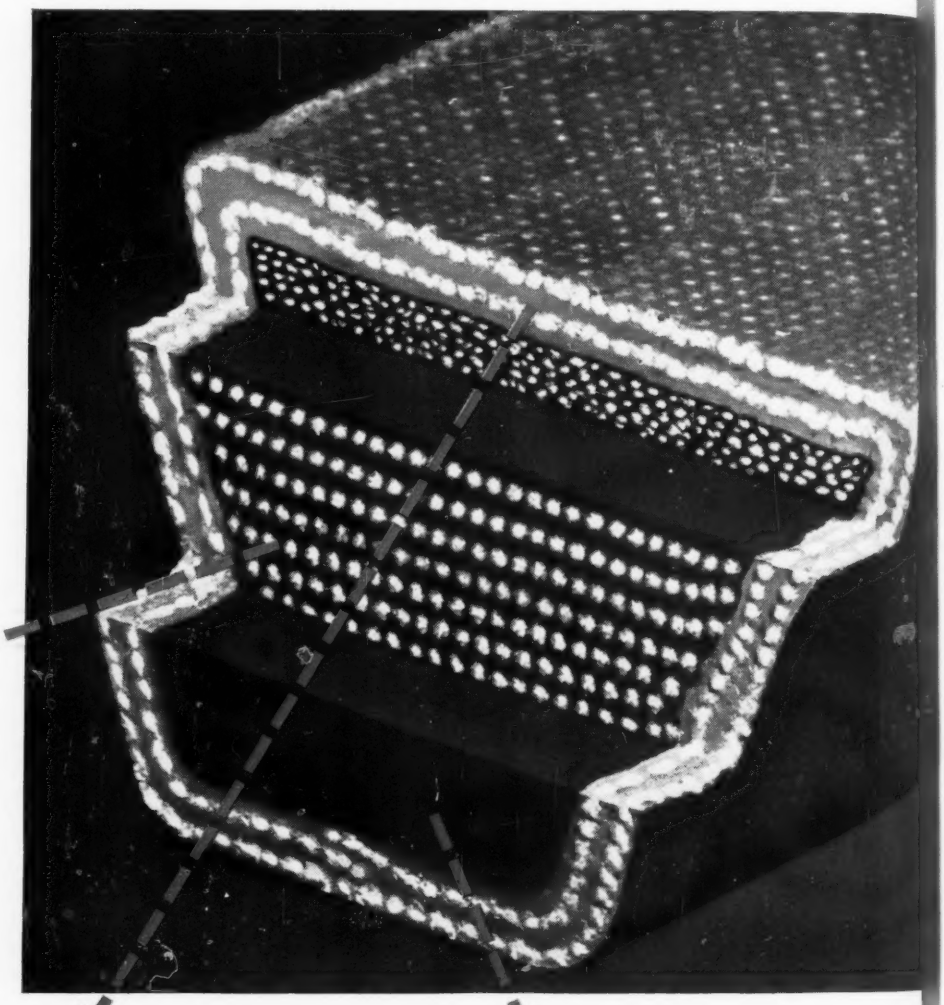

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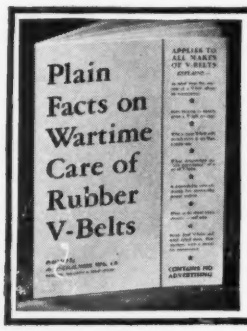

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THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

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MAIN OFFICE: The Penton Publishing Co., Penton Bldg., Cleveland, O.

BRANCH OFFICES: *New York,* 110 East 42nd St.; *Chicago,* 520 N. Michigan Ave.; *Pittsburgh,* Koppers Bldg.; *Detroit,* 6560 Cass Ave.; *Washington,* National Press Bldg.; *Los Angeles,* 130 North New Hampshire Ave.; *London,* 2 Caxton St., Westminster, S.W.1

PUBLISHED BY The Penton Publishing Co. E. L. Shaner, Pres. and Treas.; G. O. Hays, Vice Pres.; F. G. Steinebach, Secy. Published on seventh of month. Subscription in U.S. and possessions, Canada, Cuba, Mexico, Central and South America: Two years, $10; one year, $6. Single copies, 50 cents. Other countries: Two years, $14; one year, $8.

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Acceptance under act of June 5, 1934, authorized July 20, 1934.

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OFFICIAL U. S. ARMY & NAVY PHOTOS

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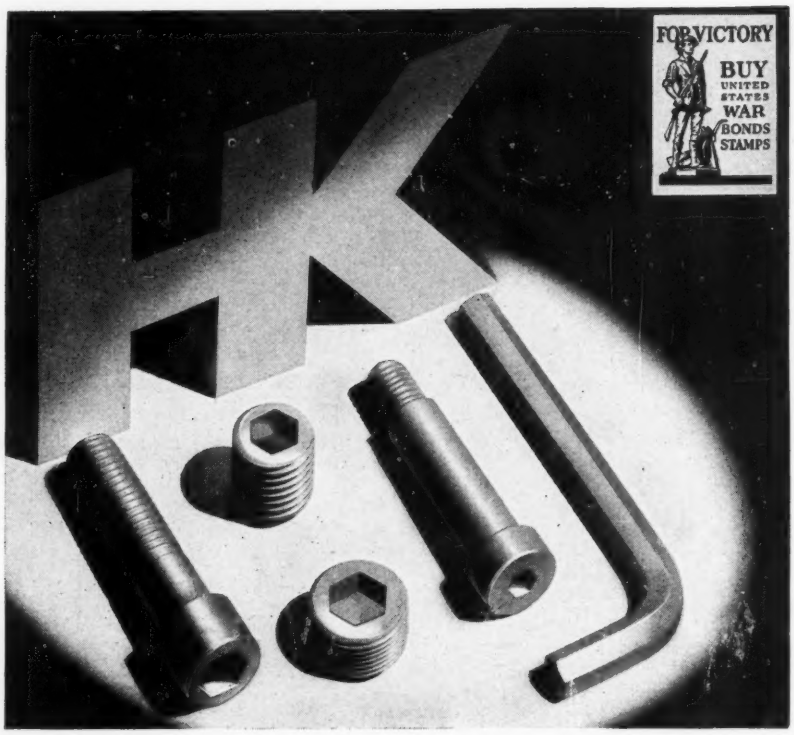

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Topics

GAMMA-RAY radiography is being used increasingly for non-destructive testing of metals to detect dangerous internal flaws before parts undergo expensive machine operations. For such testing the Navy is constantly adding to its store of radium.

♦

SIGNIFICANT is the cooperative move made by the National Synthetic Rubber Corp., jointly operated by five rubber companies, and the Rubber Reserve Co. for the operation of a goverment-owned plant. Output will be allocated by the government, as will be the products of other government-owned synthetic rubber plants.

♦

TO PROVIDE American fighting men with the safest ammunition in the world, X-ray inspection will be employed more extensively. As announced by the War Production Board, examination will assure that die-cast parts such as fuses and other components will be free from cracks and other flaws.

♦

BECAUSE camouflage paints now available do not reflect infrared like nature's colors, particularly the green chlorophyll in foliage, new pigments are being developed to make military equipment invisible not only to the eye but also to infrared photography.

♦

RECENT developments in powder metallurgy will save millions of man hours and thousands of tons of strategic metals in the 1943 war program, according to the Amplex division of Chrysler. In the production of one weapon, built by the division and utilizing 106 powder metal parts, 4,000,000 man hours and 1,250,000 pounds of metal will be saved during the year.

♦

DURING the first year of war the number of women war workers has increased by more than a half million, exclusive of office and other clerical employes, saleswomen, officials, technical and supervisory personnel.

♦

COOPERATION of industry has been requested by the War Metallurgy Committee which is working jointly with the American Foundrymens association, under the specific approval of WPB. Specific information from companies on successful applications of cast iron subject to temperatures in excess of 450 degrees Fahr. is needed. Such data would assist in relieving the overburdened steel industry by encouraging the use of more available materials. Because time is a factor vital to the program this help would be valuable. Information obtained will be reported statistically and actual details will be kept confidential when desired.

♦

ANTISHRINK treatment of wood has been developed to permanently reduce shrinkage. The method comprises continuously passing dry wood beneath the surface of a fused salt consisting of a mixture of sodium and potassium acetates that is heated to about 550 degrees Fahr.

♦

AIRCRAFT manufacturers of the East have pledged their wholehearted cooperation toward achieving world-wide American air supremacy by agreeing to pool immediately their resources of engineering, research, manufacturing techniques, facilities, materials and personnel in an all-out endeavor to attain maximum output of planes as speedily as possible. This plan has been announced by the Aircraft War Production Council, East Coast, Inc. which will serve as a clearing house for coordinating the efforts of the member companies.

♦

ONE HUNDRED TWENTY WPB forms for obtaining information from industry have been eliminated and one hundred thirty-two were improved and simplified. In commenting on the program, Donald Nelson said, "Elimination of unnecessary paper work is of vital importance to the war program. The committee has made a real and important contribution to increasing production."

♦

OPENING of a large, newly-discovered deposit of molybdenite in Canada has been confirmed by George C. Bateman, Canadian metals controller. The find is of importance to the war effort of the United Nations because of the serious shortage of molybdenum. While small compared to the largest United States deposits, it is the largest and best ever found in Canada.

MACHINE DESIGN

Where Is PATENT FUROR Heading?

By George V. Woodling

THE present controversy involving the alleged abuse of patents is not of recent origin. It dates back more than fifty years with interrupted periods of flare-up of which the latest is the most intensive. Because the crux of the issue deals with two overlapping fundamental principles which clash with each other, the problem is not an easy one to solve and will probably exist for a long time.

One of these fundamental principles arises from the patent laws which give the inventor an exclusive right to the manufacture, sale and use of his patented invention. This right is sometimes referred to as a monopoly, although in a true sense of the word it is not, as borne out by a Supreme Court decision involving a radio re-

ceiver wherein the Court said:

"Though often so characterized a patent is not, accurately speaking, a monopoly, for it is not created by the executive authority at the expense and to the prejudice of all the community except the grantee of the patent. . . . . The term monopoly connotes the giving of an exclusive privilege for buying, selling, working or using a thing which the public freely enjoyed prior to the grant. Thus a monopoly takes something from the people. An inventor deprives the public of nothing which it enjoyed before his discovery, but gives something of value to the community by adding to the sum of human knowledge."

Since the grant of the patent gives the inventor exclusive right to control his invention he may lawfully refrain from making the patented article. By the same token it is reasoned that if he has the right to refrain from making the patented article, he certainly has the right to attach restrictions to its use. It is the freezing of the invention from public use or the limited freezing of the invention by attaching restrictions to it which is one of the basic reasons for the present flare-up.

The other fundamental principle, which clashes with the patent laws, arises out of the antitrust laws which seek to prevent the restraint of trade. A portion of the law dealing with the restraint of commerce which clashes with the patent laws reads as follows:

"Every person who shall monopolize, or attempt to monopolize, or combine or conspire with any other person or persons, to monopolize any part of the trade or commerce among the several States, or with foreign nations, shall be deemed guilty of a misdemeanor. . . ."

The extent to which the antitrust laws circumscribe or limit the monopoly of a patent is the main sore spot. Between the two opposing forces there is a "no man's" land where much confusion exists. The horizon is blurred with economic and social reforms. Because of the lack of a clear line of demarcation the situation cannot be readily solved by a single piece of legislation. Even those who have been taking an active part in the present patent argument, recognizing the fact that a change in the law is necessary, are at a loss to chart the course to follow.

Before outlining several of the suggested proposals, it may be well to set forth two leading cases which serve as landmarks in the history of the struggle between the patent laws and the antitrust laws. The first case will be referred to as the "mimeograph" case and the second as the "motion picture" case.

In the mimeograph case the whole suit arose from the simple purchase of an unpatented can of ink for use upon a patented mimeograph machine, *Fig.* 1, which carried a "license" reading as follows:

LICENSE RESTRICTION

"This machine is sold by the A. B. Dick Co. under the license restriction that it may be used only with the stencil paper, ink and other supplies made by A. B. Dick Co., Chicago, U. S. A."

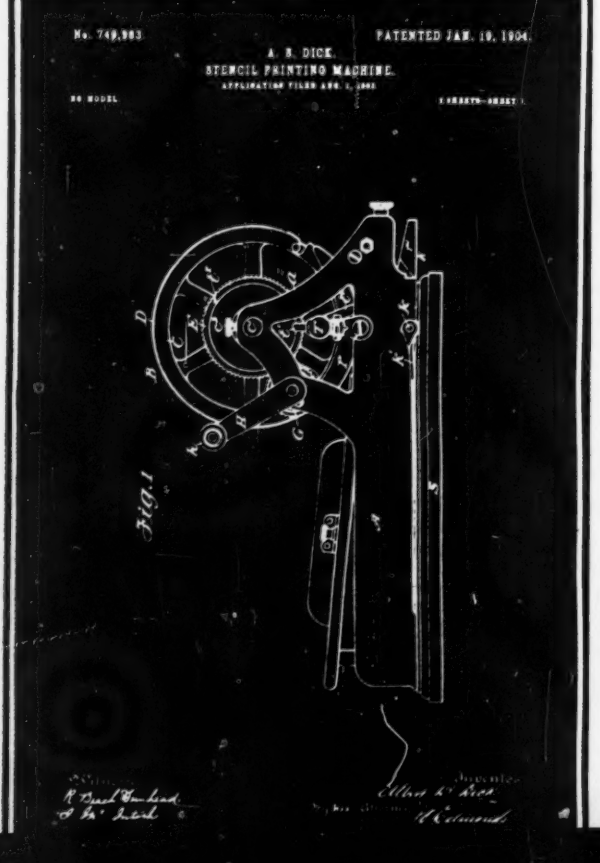
Regarding the use of special ink, the president of the company explained:

"The ink used on this type of machine is the result of long and protracted experiments of color-makers and experts employed for this purpose, repeated tests under varying conditions so as to adapt the ink to various climates and so as to have it work in harmony with the stencil paper without injury. Some years ago I discovered an ink being sold for stencil use which contained a large proportion of benzine, and as benzine will dissolve the wax on the stencil sheets it was ill-adapted for the purpose and soon destroyed the stencil and rendered it useless. We made hundreds of experiments, changing the formula each time, and finally rested with an ink which is thoroughly well adapted to the purpose intended. I found in practice that each type of duplicating machine requires an ink having peculiar characteristics in order to get the best result from the machine, and it was an ink of this character which we finally developed and put on the market for use on the rotary mimeograph."

Both the dealer and the purchaser of the ink had actual knowledge of the license restrictions and knew that the ink was being used in violation of the restriction. The real gist of the suit involved the question of whether or not the owner of a patent could extend the monopoly of the patent to include the unpatented ink. Of the nine judges, five held that the restriction was valid, one took no part in the decision, and the other three dissented.

The logic of the five judges may be explained in this way: If a patentee says: "I may suppress my patent if I wish. I may make and have made devices under my patent, but I will neither sell nor permit anyone to use the patented things," he is within his right, and none can complain. But he may say: "I will sell with the right to use, but only with other things proper for using with the machines. Furthermore, I will sell at the actual manufacturing cost of the machines, provided the buyer will agree to use only such articles as are made by me in connection therewith." If he chooses to take his profit in this way, instead of taking it by a higher price for the machines, he has not exceeded his exclusive right under the patent laws. The market for the sale of such articles to the users of his machine, which, by such a condition, the inventor takes to himself, was a market which

Fig. 1—Below—Purchase of a can of unpatented ink for use on this patented machine initiated furor



he alone created by the making and selling of a new invention. Had he kept his invention to himself, no ink could have been sold by others for use upon machines embodying that invention. By selling it subject to the restriction he took nothing from others and in no wise restricted their legitimate market. The machines were sold at cost. They were therefore purchased by many who, had a manufacturing profit been added, would have been unable to enjoy the patented inventions. The patentee's profits on the supplies represented royalty; this accrued only in proportion to the licensee's use of his machine. By using the patentee's specially adapted supplies, licensees obtained work of high quality and the reputation and prestige of the machine were preserved.

The "mimeograph" case was decided in 1912, and paved the way for a broad patent license program to be adopted by large companies. The commercial effect of the decision was substantially equivalent to legislation by the Supreme Court on a matter of economic policy dealing in patents and, as we shall presently see, it required the combined effort of Congress and the courts to overthrow the effect of the decision. Congress soon saw the evils of such a decision and in 1914 passed the Clayton act which, among other things, made unlawful the creation of a monopoly in any line of commerce as sanctioned by the "mimeograph" case. The main object of the Clayton act was to prevent any sort of trade arrangement which substantially lessened competition, and a portion of the law on the subject reads thus:

"It shall be unlawful for any person engaged in commerce to lease or make a sale or contract for sale of goods, wares, merchandise, machinery, supplies, or other commodities, whether patented or unpatented . . . . on the condition, agreement, or understanding that the lessee or purchaser thereof shall not use or deal in the goods, wares, merchandise, machinery, supplies, or other commodities of a competitor or competitors of the lessor or seller, where the effect of such lease, sale, or contract for sale or such condition, agreement, or understanding may be to substantially lessen competition or tend to create a monopoly in any line of commerce . . ."

Previous Decision Overruled

In 1917, five years after the "mimeograph" case, the Supreme Court reversed the case in a suit involving the motion picture apparatus shown in *Fig.* 2. This case involved substantially the same legal question as in the "mimeograph" case. In the "motion picture" case the agreement contained a restriction which specified that the motion picture machines shall be used only with films obtained from specified sources. The Supreme Court held that it was unlawful to extend the patent monopoly covering the projection machines to include the unpatented films and this case marked a turning point in the law of patents. Although the Clayton act was passed prior to the decision of the "motion picture" case, the Supreme Court reversed itself without relying upon the Clayton act. The Court said: "Our conclusion renders it unnecessary to make the application of the statute (Clayton act) to the case at bar . . . . and the conclusions arrived at in this opinion are such that the decision in the "mimeograph" case must be regarded as overruled." It is recalled that in the "mimeograph" case, the Supreme Court praised the merit system which restricted the use of the patented machine to unpatented supplies, and in

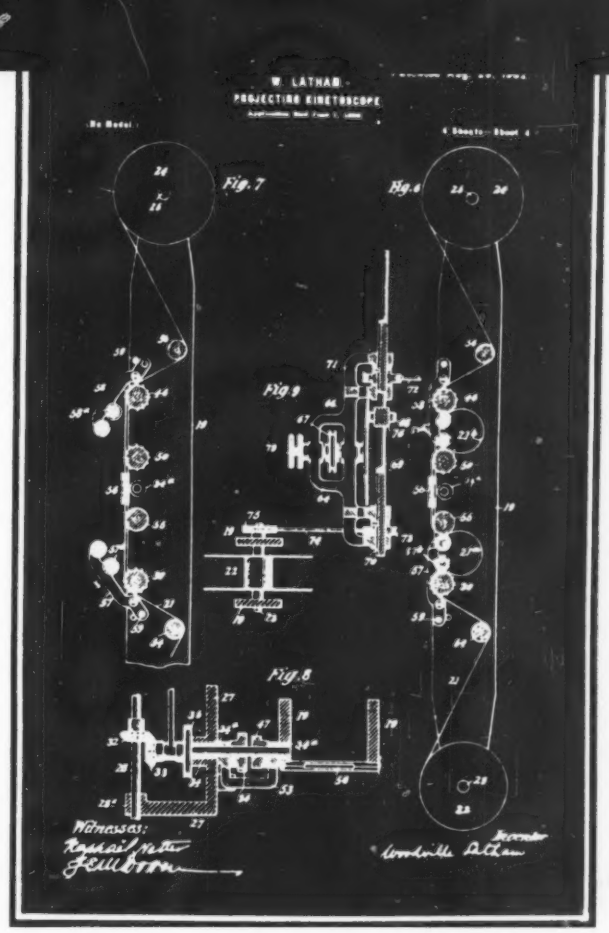


Fig. 2—Supreme Court decision in motion picture case paved the way for restrictions of patent laws by antitrust laws

which the owner of the patent made his profits from the sale of his unpatented supplies. Note the change in language which the Court used five years later in the "motion picture" case which now condemns this practice. The Court now points out:

"Such a restriction is invalid because such a film is obviously not any part of the invention of the patent in suit; because it is an attempt, without statutory warrant, to continue the patent monopoly in this particular character of film after it has expired, and because to enforce it would be to create a monoply in the manufacture and use of moving picture films, wholly outside of the patent in suit and of the patent law as we have interpreted it. . . ."

From this time forward, the antitrust laws became increasingly effective in circumscribing the patent laws. Although the "motion picture" case legally put a stop to the extension of the patent monopoly to include unpatented supplies, many other types of restrictions have been tried by patent owners to make patents as effective as possible to lessen competition.

The present controversy regarding the alleged evils of patents is primarily directed to these new methods. As to the proposed changes, it is believed that the remedy lies in an amendment to the antitrust laws so that its application to patents would be clearly defined. As a further curb upon patents, the law might provide that the department of justice may intervene in patent law suits on behalf of the defendant to ascertain whether the patent owner is violating any antitrust laws at the time he brings his patent law suit.

This proposal would strengthen the antitrust laws, would operate to curb large corporations and would probably free the small business man from injury, as distinguished from the proposed compulsory licensing law which would operate to damage the small business man

more than the large corporations. This appears to be the biggest objection to compulsory licensing. The idea of a compulsory license law is not new as it has been under congressional discussion many times, but apparently the country is not prepared to accept it, primarily because of the attitude of the small businessmen. This is clearly brought out in hearings at Washington, and the following is representative of the attitude:

"We do not believe that in our small company the compulsory licensing of patents would in any way help employment or progress or limit the activities of the larger corporations as against the smaller ones.

"Due to the protection of this patent, which we purchased along with others, we have been able to build up a fairly secure volume of business. It is enough to pay 100 men well, keep them working steadily. . . . .

"We are definitely against any kind of licensing of patents

Fig. 3—Unwise changes in patent laws would discourage development of ideas as depicted above

which will take away the only protection that we little men have against big corporations."

It appears logical that compulsory licensing of patents would force thousands of small manufacturers to drop out of business, because without the aid of patents the small manufacturer would not be able to compete effectively with the large concerns. Furthermore, the public would lose in the long run because the immediate effect of compulsory licensing would be to limit the opportunities for inventors to develop new ideas in numerous small laboratories, *Fig.* 3. Use of patents by the smaller competitor is the best means of keeping the large corporation from lessening competition. In other words, patents in the hands of the small manufacturer become substantially as effective in curbing the monopolistic practice of large corporations as are the antitrust laws.

Another proposal is the passage of a bill for a Federal Patent Commission which would administer the licensing of patents in the interest of the public, with about the same general powers as now are vested in the Federal Trade Commission and the Federal Communications Commission. Proponents of such a bill point out that the problems involved in the exploitation of patents are of many types and are too complicated to be solved by a single legislative remedy of Congress. This bill would lay down certain broad legislative policies and would leave it to the Commission to study each isolated patent situation and apply a solution which would not be inconsistent with the general legislative policy of the bill. Proponents of the bill further point out that there would be no inequitable distinction between big business and little business, as the Commissioner would take into account the facts existing in each case and thereby apply a ruling which would be equitable both for the large and small concern. The main object of the Commission would be to prevent lawful exploitation of patents against the public interest. There is much to be said in favor of such a bill, as it would probably function to clear away many abuses. Whether the Commission could effectively handle "heavy" cases is doubtful; thus the burden would probably have to be placed upon the courts. Therefore, about the most that can be said for a Federal Patent Commission is that it would be effective in handling a lot of small abuses. On the contrary it might stir up considerable unnecessary trouble. As to the "heavy" cases, these would probably have to be decided by the Supreme Court as they always have been.

The same complaint may be lodged against the proposed licensing law because here again the patentee would have recourse to the courts in the event that he was not satisfied with the proposed license as worked out by the Commissioner of Patents, with the result that the final disposition of the case would have to be decided by the Court. If the case is to go to the courts anyway, it might as well be started in the first instance by an action under the antitrust laws.

Antitrust Law Amendment Favored

This leads one to the conclusion that possibly the best solution for the correction of whatever evils might exist is to amend the antitrust laws and especially to define clearly the boundary line between patent rights and the antitrust laws to avoid the present confusion. Besides defining this boundary, the amendment might require all patent license agreements to be recorded with the antitrust division of the government, so as to facilitate the inspection of such agreements. Little policing would then be required by the government to find violators.

The confused situation in which industry finds itself, between the Scylla of patent laws and Charybdis of antitrust laws, may be hampering the full development of inventions more than does any alleged shelving of patents. With clarification of the laws, industry can establish policies for the handling of inventions and patents without fear of legal complications. Already a number of industrial concerns have modified their patent policies to make inventions more available to the public and to lessen competition in the trade. Similar policies might extend to all industry as a result of clearing up confusion.

In formulating essential revisions Congress must depend to a large extent on the advice of those most closely affected by the laws. The guidance which industrial leaders can furnish legislators in congressional hearings or otherwise can have beneficial and far-reaching effects.

Scanning the field for IDEAS

—U.S. Navy official photo

Extreme service conditions such as met by Navy equipment in Icelandic waters or the South Pacific require materials equal to the task. Lubrication of the magazine for the Oerlikon rapid-fire antiaircraft gun shown at left is a typical example. Containing a large coil spring to "pass the ammunition" the magazine must operate perfectly and freely under all situations and must be protected against corrosive action of salt spray. A lubrication, known as Plastic Petroleum B, developed originally for business machines has been found to meet these exacting conditions. In the illustration one crew member is removing an empty magazine and another is bringing up a refill. The canvas bag catches empty shells.

Eleven-year creep test at high temperature on four high-strength alloy steel rods, left, has just been completed by General Electric to determine what stresses could be used without causing deformations larger than the minute values tolerable in high-speed machines. Such a prolonged test also provides means for studying the changes in characteristics of the metal. The alloy tested was SAE 4340, a nickel-chrome-moly steel, using four specimens each four feet long and .505-inch diameter. A twelve-inch section at the

center constituted the test area. Temperature of the furnace was maintained at 842 Fahr., and the four rods were subjected to stresses of 13,000, 17,000, 21,000 and 25,000 pounds per square inch. In this 100,000-hour test, the rods stretched .928, 1.398, 2.729 and 4.166 mils per inch length, respectively.

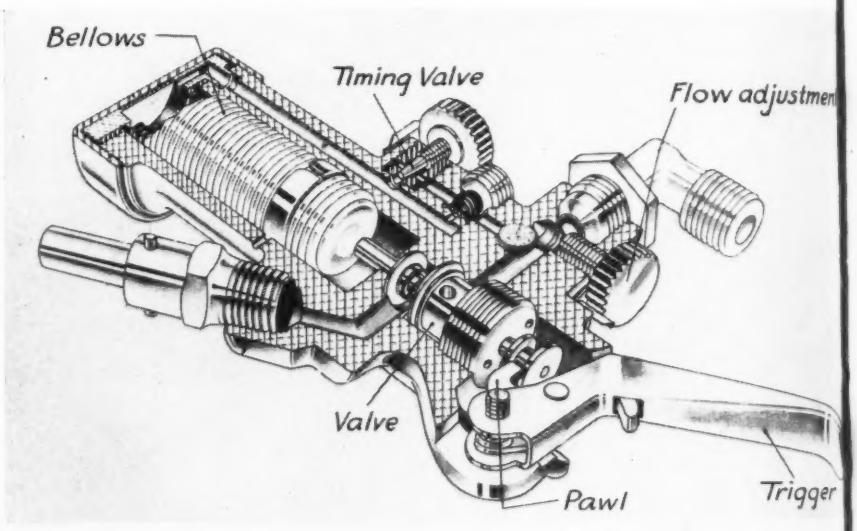
Pneumatic timers offer effective control and simplicity in design for time delays on contactors, etc. For portable pneumatic tools a timer, designed by the Murray Corp., greatly extends their application especially by inexperienced hands. Applied to riveters the timer illustrated facilitates the production of accurately formed rivet bucktails of uniform height and diameter, avoiding usual rehitting or overhitting which requires drilling out and replacing. Also, overhitting would result in hardening and thus weaken the structure. Designed for all conditions of flexibility in control that might be met, the timer is operable or inoperable, depending upon the position in which the trigger is held so that odd size rivets may be driven without changing the timing, preset for other rivets.

Referring to the perspective cross section, timer is interposed between air-line hose and riveter. Cycle is started by pressing the trigger. By means of a pawl, this operates the valve on a valve stem spool. Air for operating the hammer may then pass through the unit. Part, however is metered through a needle valve into a bellows. This causes the bellows to extend until its end strikes the valve stem, urging it forward and completing the timing cycle.

Time of cycle is dependent upon the time required to build up sufficient pressure in the bellows to close the main valve. Air used in the timing element is then exhausted through the gun, allowing the bellows to return to normal. A by-pass valve permits quick return so that a following cycle may be initiated without delay. Air stored in the bellows is not sufficient to operate the gun and therefore passes through it without notice.

Adjustment screw controls the flow of by-pass air to the timing chamber, thereby controlling the length of timing cycle. A second adjustment screw controls the flow of direct air to the gun which determines the weight of the blow. Proper balance between these adjustments provides for any automatic preset conditions. When trigger is held in extreme position timer is inoperable, providing complete flexibility in service through the single trigger control.

Filters at two points protect the unit against damage resulting from foreign particles lodging in the valves. Fine screen

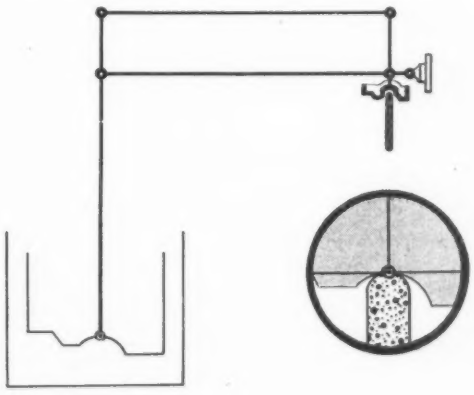


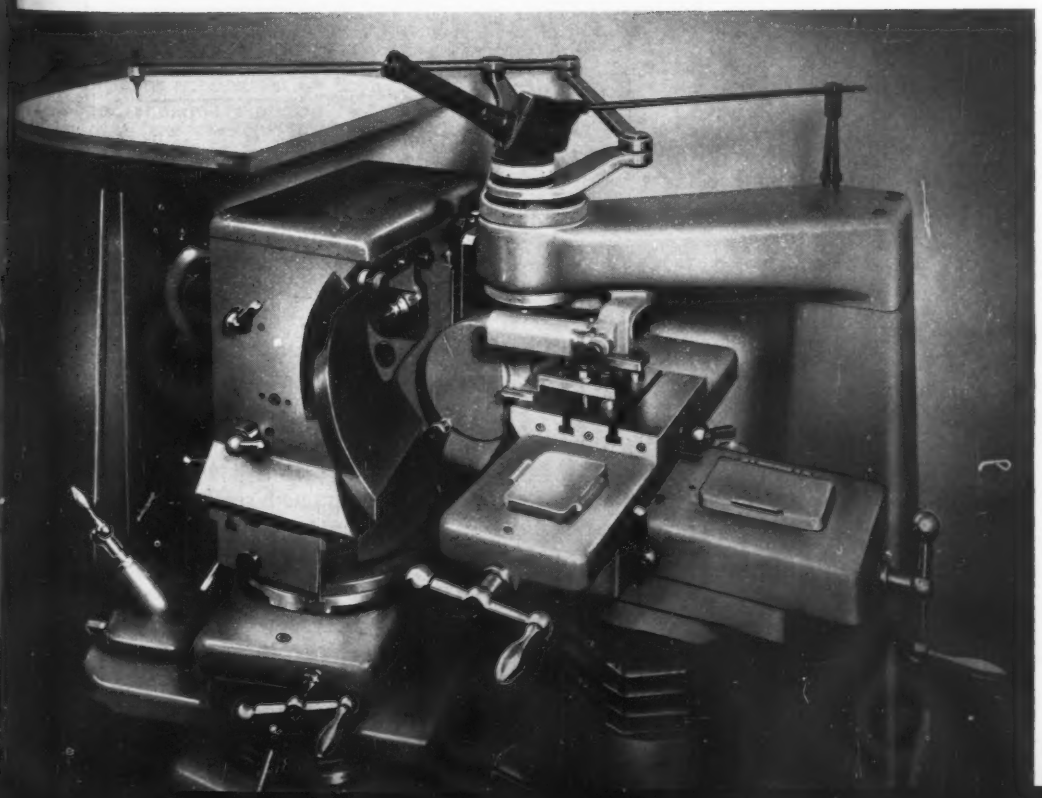
cloth at the inlet filters all air passing through to the gun. A secondary or finer filter, consisting of a felt pad, assures that air reaching the timing chamber is free from tiny particles that would pass the screen but have an adverse effect on the needle valve, or alter the timing period. This pad is so located that its surface has a self-cleaning action due to passage of direct air to the gun.

To retain compactness and have convenient position of trigger involves the release of the pawl from the spool when affixing to the gun. This releases the handle to open position, thus providing adequate clearance for assembly. All parts are designed for easy maintenance such as a screwed-on cap at end for removal of bellows without affecting valve adjustments. Body is aluminum die casting because light weight is essential to portable tools, this feature ranking in importance with those of convenience, balance and dependability.

Gem quality synthetic sapphires have been produced in the form of boules which may be cut and sawed into shapes for precision bearing surfaces as used in aircraft instruments and other exacting applications. Shown at left are two boules produced by Linde Air Products Co., one being 200 and the other 350 carats. Because these synthetic sapphires have melting points well over 3700 degrees Fahr., they are applicable where high heat resistance is required.

Optical-pantograph arrangement on the grinder, below, provides means whereby an operator can grind profiles within .0004-inch accuracy or better. Pantograph linkage for this Wickman machine is shown in the accompanying schematic sketch and is arranged to give a 50:1 reduction. The microscope is carried on the short arm of the pantograph and is





focused on the work so that the intersection of cross hairs in the field corresponds to the position of the pointer on the pantograph. Accurate enlargement of an unknown profile also is readily accomplished by reversing the operations and drawing a profile with the pointer, keeping the cross hairs on the piece at each position.

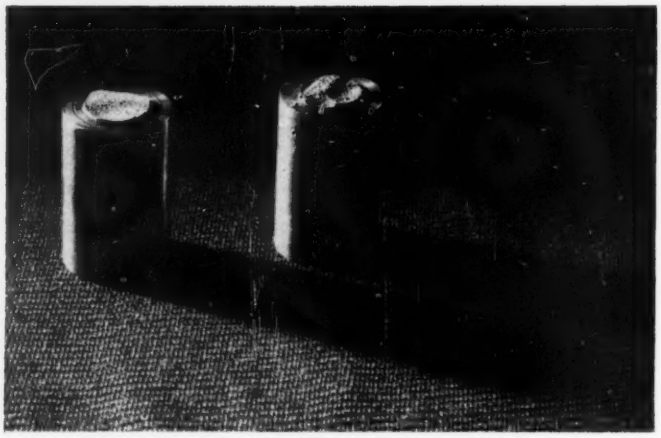


Fig. 47—Fine fracture structure of specimen on left is indicative of high impact strength and generally improved serviceability

Wartime Metallurgy

By R. E. Orton and W. F. Carter
Acme Steel Co., Chicago

GRAINS being the bricks from which metals are built, it is not surprising to find that their size has a material influence on characteristics. Ancient hardeners realized that a hardened steel that broke with a fine silky fracture was tougher than one that showed a coarse texture.

In *Fig.* 47 are shown two specimens quenched and tempered to identical hardness. The sample on the left carried nearly four times the impact loading of that on the right. Corresponding improvements would be found in its ductility and, in fact, in its general reliability in service. While such improved qualities had for long been associated with a fine fracture, only in comparatively recent years has it been appreciated that this silky fracture reflected a fine grain size—that the improved qualities were associated with the fineness of the grain.

Is Second Only to Hardenability

Marked lowering of the hardenability with reduction in the grain size is found in steels apparently identical in all other respects. This, together with the other characteristics modified by grain size, has placed it on the heat treater's list second in importance only to hardenability.

Effect of grain size on the brittleness is brought out in *Fig.* 48, taken from Bain[1]. While, as Bain himself points out, such consistency of tests will not usually be experienced, the general trend is indicated. Here a change from coarse to fine grain has increased the impact strength of the material three times.

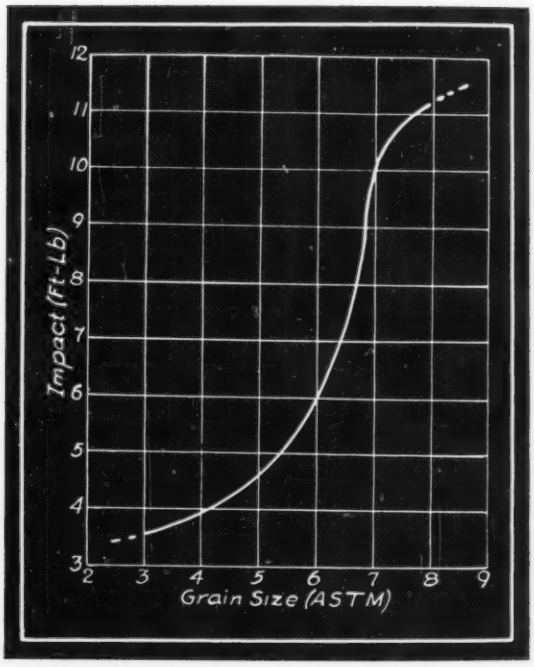


Fig. 48—Impact strength varies widely with the grain size as shown. Miniature specimens heat treated to rockwell C 50

The improvement in ductility due to fine grain size is not as pronounced as is the impact. Strength and yield are slightly reduced although the effect is not pronounced. There is little data on fatigue properties even though it is generally believed that the endurance strength is raised somewhat by reduction in grain size. The "notch effect" is very markedly affected. As previously discussed*, coarse grains better resist the initiation of a fatigue crack; fine grains better resist the spread of a crack once initiated.

Summing up, there is general agreement that a fine grain structure gives greatly improved serviceability for highly stressed parts at ordinary or subnormal temperatures. For high temperature service there is reason to feel that a coarse grain structure will show a lower creep.

Machinability is generally improved by a coarse grain structure, but the finish with a fine grain will usually be superior. In general, both hot and cold formability are improved by a coarse grain, although it has been found on some difficult deep drawing jobs that one particular grain size (generally in the neighborhood of ASTM 7) gives the best results. Coarse-grained steels tend to a roughened surface in severe drawing, so that for some purposes a finer grain may be required. The coarse-grained steels are more susceptible to grinding cracks than are the fine.

Grain size effect on hardenability is brought out by

[1] References are listed at end of article.
*Machine Design, Page 73, September 1942.

Conserves Strategic Materials

Part VI—Grain Size

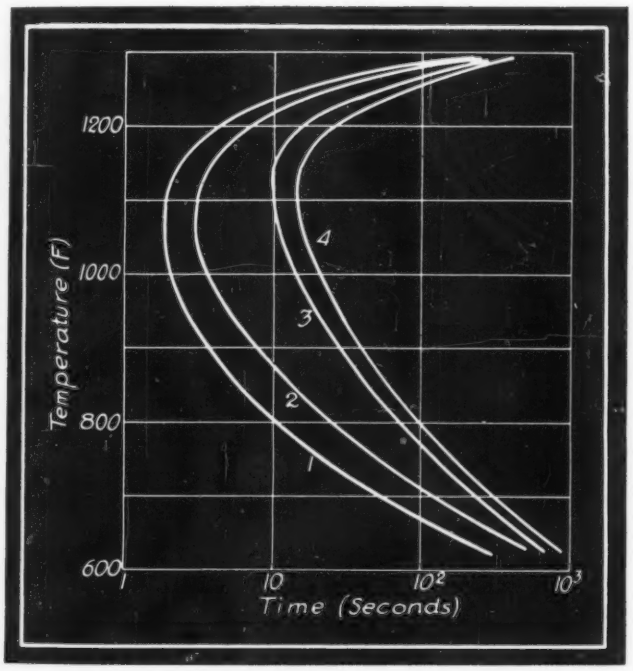


Fig. 49—Coarsening the grain structure shifts the isothermal curves toward increasing time. Fifty per cent transformation curves for ASTM grain sizes as follows: No. 1, 8 to 9; No. 2, 7 to 8; No. 3, 4 to 5; No. 4, 2 to 3

the curves in *Fig.* 49, from Davenport[2] showing 50 per cent transformation at various grain sizes. For this range the transformation time at the gate is increased five times. Increase in hardenability will increase depth of hardening, as brought out in the hardness traverses of *Fig.* 52, from Bain[1]. Owing to the harmful effects on physical properties, increasing the hardenability by increasing the grain size is seldom permissible. Formerly it was thought that quenching from higher temperatures increased the cooling rate, increasing thereby the depth of hardening. This has been disproved. The cooling rate is but slightly affected. It is the grain size that is increased, increasing thereby the hardenability.

Illustrating the effect of grain size on hardenability, *Figs.* 50 and 51 show surface characteristics of a link of SAE 1045. This link hardens in oil at the surface only with gradients as shown in the contour drawing in *Fig.* 50. Heating to 1825 degrees for one hour coarsens the grain to give, after tempering, a uniform hardness of rockwell C 40 to 42 over the entire surface.

A coarse grain structure increases warpage and danger of cracking in heat treating. Where cracking does not

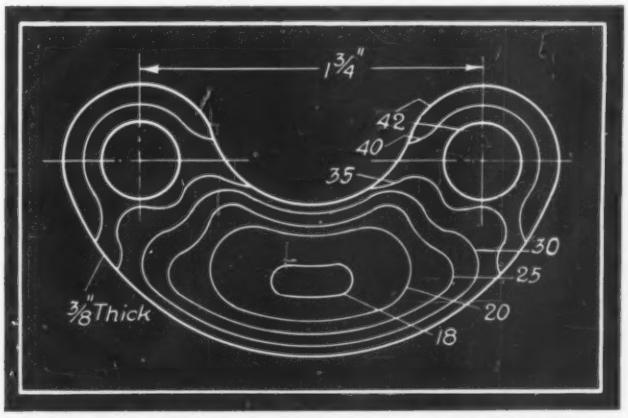
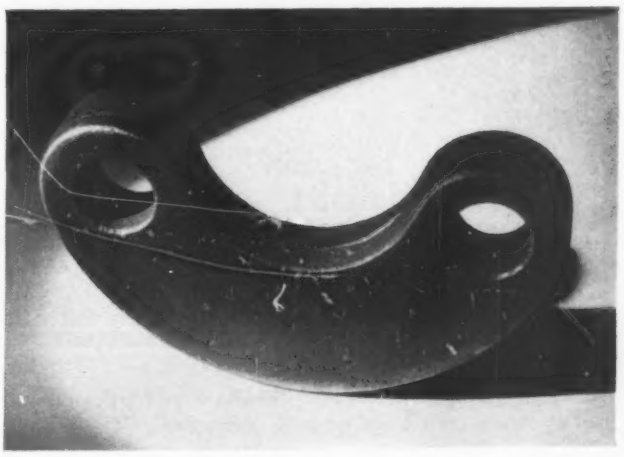


Fig. 50—Curved link of SAE 1045 fine grained (ASTM 6 to 8) hardens in oil at surface only as indicated by contour lines for various rockwell hardnesses

Fig. 51—Heating the link shown in Fig. 50 to 1825 degrees for one hour coarsens grain structure, the hardenability increasing thereby to give a uniform hardness of rockwell C 40 to 42, after tempering, over entire surface



occur, the quenching stresses are increased greatly. This effect probably is due to the greater hardenability of the coarse grain rather than to the coarsened structure itself.

It may seem surprising to refer to the "grain size" of a fully hardened steel. From the nature of martensite it would be expected that, if a crystal formation existed at all, it would be submicroscopic in size. Certainly it would not be reflected in the fracture structure, which is macroscopic in its character. Such is probably the case in so far as the martensitic grain is concerned. What the fracture structure shows and what affects the characteristics of the steel, is the size of the austenitic grain existing just prior to the quenching operation. To understand how this "prior austenite grain" which is apparently "destroyed" during the quenching operation nevertheless leaves its imprint on the steel, it is necessary to inspect the mechanism of the formation of the grain and its transformation into martensite.

How Grains Form

When a eutectoid steel is heated to just above the critical, the alpha iron recrystallizes in the gamma form and dissolves the carbide to form the solid solution austenite. Nucleation of the new crystals begins at undissolved foreign atoms. This is probably due to the strained condition of the crystal structure at those points, promoting thereby the realignment of the iron atoms into the new form. The tendency to nucleate varies so that some crystals start forming before others. These develop to larger size before being interfered with by their neighbors. They are then able to "overpower" their smaller neighbors, absorbing them until all crystals in their vicinity are of a fairly uniform size.

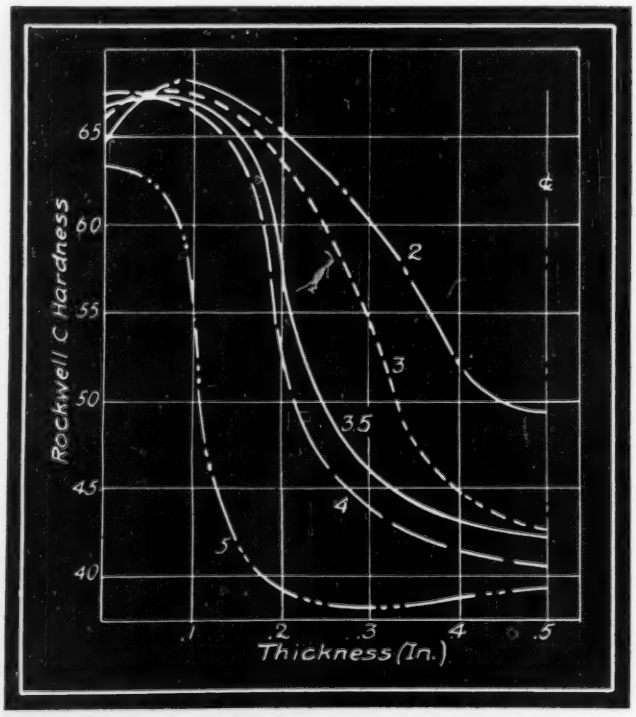


Fig. 52—Influence of grain size upon hardenability is shown in hardness traverses. Numbers on curves refer to ASTM grain sizes. One-inch diameter, .75 per cent carbon steel specimen was used

In the meantime, the carbon atoms diffuse through the austenite, crossing crystal boundaries where necessary and achieving a fairly uniform distribution. Other foreign material, of a less soluble nature, is for the most part rejected to the grain boundaries where its presence acts as an enveloping membrane tending to prevent further grain growth. By this time a fair degree of stability exists, there being little change with long holding at a temperature just above the critical. This first stage is reached quickly, a fairly uniform grain size and homogeneous austenite (as far as the carbon is concerned) being achieved in a matter of minutes.

The "initial austenitic grain size" depends primarily upon the number and distribution of the nucleating points. The greater the number of nuclei, the greater are the number of grains and the smaller their size.

Presence of undissolved material in the boundaries hinders grain growth. Increase in the temperature increases the tendency for growth, and also the solution of this boundary material. If the quantity of undissolved material is low the grains will coarsen gradually. If the quantity is large there will be practically no growth with increase in temperature until, at some high value, the tendency to grow becomes great enough to overwhelm rapidly the restraining action of the material remaining undissolved, the grain then coarsening with great suddenness.

Factors Controlling Grain Growth

Like all metallographical reactions, grain growth is a matter of time as well as temperature. At lower temperatures the absorption of undissolved material does proceed, but at a low rate. Likewise, grain growth probably does occur, but again at so slow a rate as to be inappreciable. The rate increases with rise in temperature so that holding too long a time near the coarsening temperature will result in eventual coarsening of the structure.

With a hypoeutectoid steel the same change occurs in the pearlite grains on heating above the pearlitic line. The undissolved free ferrite acts to block further growth until it is absorbed on passing the ferritic line. The austenite then develops the same as for the eutectoid steel.

With a hypereutectoid steel the action is similar except that the absorption of the excess carbide is sluggish. If the composition is appreciably above the eutectoid, prolonged holding above the carbide equilibrium line is required for solution. These excess carbide particles act as does foreign material, promoting the formation of a fine grain and hindering grain growth.

Upon lowering the steel below the critical, recrystallization to alpha iron commences. Nucleation proceeds again from the undissolved particles and since these are in the boundary for the most part, crystallization begins there and progresses inwardly in each grain. This, together with the undissolved particles which remain in the boundary, marks out the prior austenite grain.

There is reason to believe that something approaching the atomic orientation existing in the austenite prior to the quench persists in the quenched martensite. Recently developed etching techniques[3, 4] bring out this

austenitic grain. While it is commercially feasible thus to bring out the grain (suitable for microscopic examination to determine size) the technique of preparing a specimen for photographing is extremely difficult. Some remarkably fine illustrations[3] have been published.

Probably all tool steels and the great majority of open hearth bar stock are produced today with grain size control. By providing the proper amount and kind of slowly soluble (or insoluble) materials, control is exercised over the nucleation, thus producing a steel with a fairly definite *initial* austenitic grain size. The proper amount of these insolubles will then substantially maintain this initial size up to some fairly definite coarsening tempera-

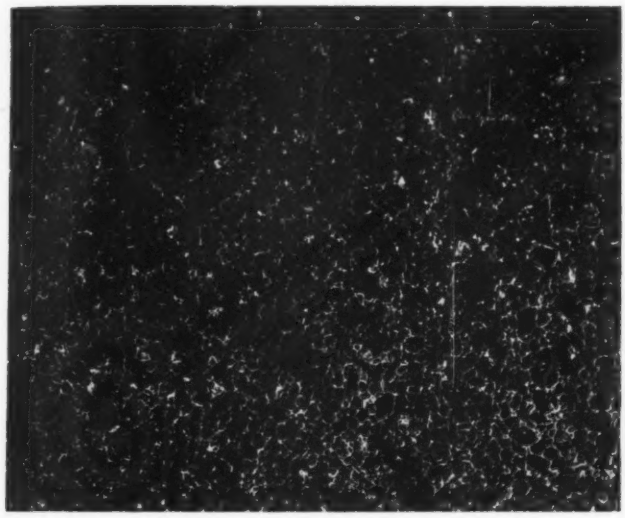


Fig. 53—Grain size in hypereutectoid steel. Boundary network is free carbide. Dark etching portions are pearlite. ASTM grain size 9. Magnification 100 diameters

ture. This practice has greatly aided the heat treater—there no longer being the need for great care to prevent overheating, or too long holding at temperature.

While the initial austenitic grain size is little affected by prior heating operations, the coarsening temperature may be markedly affected. Heating and cooling at a moderately slow rate will usually *lower* the coarsening temperature 50 to 100 degrees, instances have been reported up to 200 degrees. No adequate explanation for this phenomenon exists. It is therefore difficult to find any consistency in the effect.

Standards have been adopted for evaluating grain size, that of the A.S.T.M.[3] having the widest acceptance:

A.S.T.M. Grain Size Standards

Size No.	Average grains per sq. in. at 100 diameters
1	1
2	2
3	4
4	8
5	16
6	32
7	64
8	128

It should be remembered in grain size determinations that the examination is of a cross section through the grains. Therefore, even if the grains were all uniform

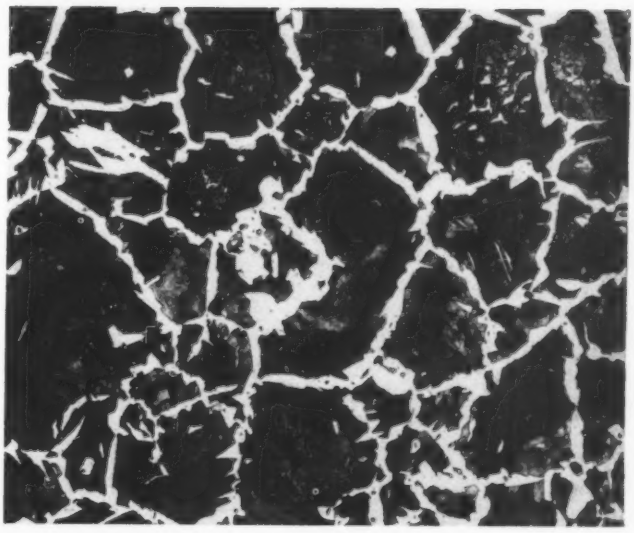


Fig. 54—Grain size in hypoeutectoid steel. Boundary network is free ferrite. Dark etching portion of grain is pearlite. ASTM size 2. Magnification 100 diameters

in size, there would be a variation in the section size owing to the fact that some grains would be cut near their ends, others at their largest dimension, etc. Small grains scattered throughout the picture are therefore not indicative of mixed grain size. A mixed, or "duplex" structure is indicated by a group of small grains accompanying a number of large ones. Such a duplex structure usually indicates that the steel was caught at its coarsening temperature.

Grain Size Determined by Indirect Methods

It is not necessary to determine the austenitic grain size by direct etching of the fully hardened martensite. Grain is not altered by the method of cooling from the austenitizing temperature, making it possible to reveal the size by indirect methods. Because of the wide use and application of several of these methods they are outlined in the following:

On slow cooling of hypereutectoid steel the excess carbide is precipitated in a network structure of free carbide, outlining the prior austenite grain. The remaining austenite then transforms to pearlite, giving a micro of dark-etched pearlite surrounded by a well marked network of light-etched carbide. This structure is illustrated in *Fig.* 53.

Cooling at the proper rate will result in rejection of free ferrite at the grain boundaries of a hypoeutectoid steel, the lighter etching ferrite outlining the dark pearlite grains similarly as the free carbide outlines the hypereutectoid steels. This type of formation is illustrated in *Fig.* 54.

Steel of the eutectoid composition may be brought out by quenching one end of a bar in water, the other end being allowed to cool in the air, somewhat as in the Jominy end-quench test for hardenability†. At some point along the bar an intermediate cooling rate will be found such that the transformation will not have been completed across the grain before the center has been carried down below the gate of the isothermal curve. As

†MACHINE DESIGN, Page 94, December 1942.

a result the center portion of the grain will be transformed to light etching martensite, the boundaries to dark etching emulsified pearlite.

The enlargement of the micro should be borne in mind in considering grain size. This is illustrated by *Fig.* 55, taken at 200 diameters, or twice the standard for size rating. The "apparent grain size", that is, the size as determined without regard to enlargement, is 5½. The actual size is much finer. The relationship between true size number N, and apparent size N_d is

$$N = N_d + 6.6 \log_{10} d$$

where d is the enlargement divided by 100. For an enlargement of 200, $d = 2$ and

$$N = N_d + 6.6 \log_{10} 2 = N_d + 2$$

giving $N = 7\frac{1}{2}$ for *Fig.* 55.

The McQuaid-Ehn test is the earliest metallographic method of delineating the austenite grain. It occupied

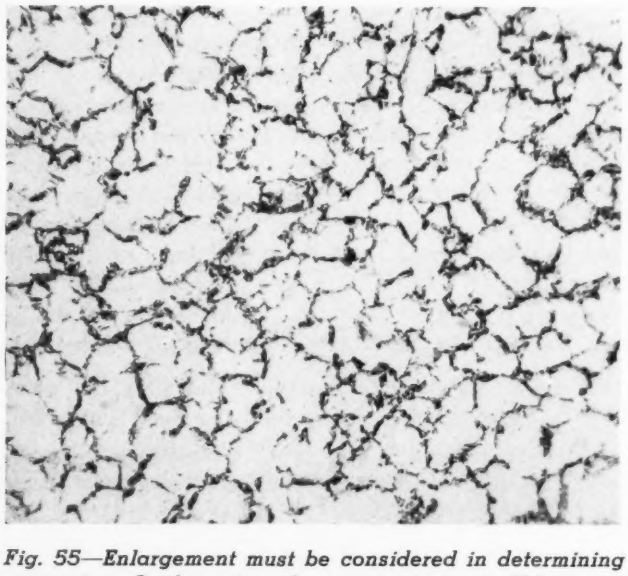


Fig. 55—Enlargement must be considered in determining grain size. In this micro the apparent size is 5½, actual is 7½. Structure martensitic with grain boundaries outlined by pearlite, from intermediate quenching rate. ASTM size 7½. Magnification 200 diameters

the field so long before other satisfactory methods were developed that it has become a standard. Where grain size is specified without qualification, determination by the McQuaid-Ehn test is usually implied. This test, developed originally for low carbon carburizing steels, has been applied to steels of all carbon contents up to the eutectoid. As performed[5], a sample is carburized for eight hours at 1700 degrees, and then slowly cooled. The carburizing compound is such that hypereutectoid case is produced. Slow cooling permits the rejection of the excess carbide as a network around the grains, the result being the same as in the treatment of hypereutectoid steels, illustrated by *Fig.* 53.

It should be noted that the McQuaid-Ehn test shows only the grain size at the end of eight hours at 1700 degrees, and as it may be modified by the particular carburizing compound used, and nothing more. Since, in many applications, the steel will not be subjected to such severe usage, and in others will be heated to even higher temperatures, the indiscriminate use of this test should be discontinued.

In the introduction mention was made of the correlation between the fracture structure and the austenitic grain size. This correlation is so close that it is the basis of an effective nonmetallographic method of determination, the Shepherd fracture standards[3]. These standards were initiated, long before this correlation was appreciated, in realization of the fact that the character of the fracture reflected many of the qualities of tool steels. These standards are now graded in such a way that the fracture number shows close agreement with the A.S.T.M. grain size number. Fractured standard bars, graded in integral steps, are available for comparison. There has recently been published excellent stereopticon photos of these fracture standards[6].

The fracture test has a great deal to recommend it for control purposes. It may readily be made on actual service parts by nicking and fracturing. It may also be used to determine the depth of hardening by the difference in the appearance of the fracture between the hardened portion and the unhardened.

In conclusion, it will be seen from the foregoing that salient points of this article are: Fine grain size steel improves serviceability of highly stressed parts; grain size control is possible by the addition of the proper quantity of certain insolubles which provide nucleation and prevent grain growth; fracture of hardened steel is related to grain size; and fine grain size lowers hardenability.

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(End of Part VI)

SIMULATING speed of falling bombs, this wind tunnel at the Westinghouse East Springfield plant tests the critical action of fuses. Testing with wind velocity of 500 miles per hour reveals what happens during actual bombing raids. Air in tunnel is controlled by a reducing nozzle and is started and stopped by a quick-acting valve. Timer measures duration and gage indicates pressures before and after operation.

Rubber Compounds as Resilient Mountings*

By Baxter C. Madden
Captain, Air Corps
Wright Field

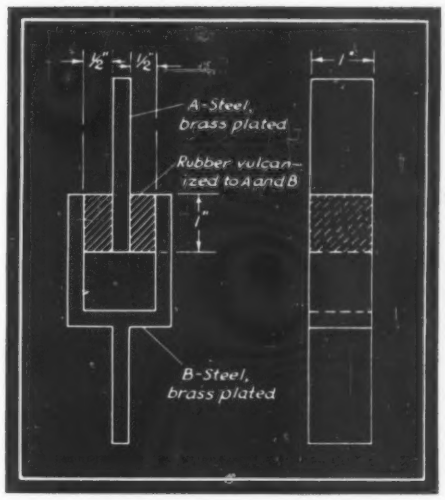


Fig. 1—Rubber machinery mounting used experimentally stresses the material in shear with vertical loading

RUBBER is widely used as the elastic medium in machinery mountings because of its resiliency, inherent damping, lack of static friction, excellent sound-absorbing quality, strong adhesion to metal, and because it requires no lubrication. While gum-rubber compounds may not be available in quantity for some time, the principles set forth in the following may be applied equally well to rubberlike materials.

The investigation upon which this article is based was concerned with determination of the effectiveness of various rubber compounds, stressed principally in shear, in the isolation of vibrating machinery. This refers to the mechanical and dynamic properties of unaged rubber compounds, without reference to qualities such as drift, oxidation, or continuation of vulcanization.

The general case of a machine supported by an elastic mounting, in which six degrees of freedom exist, was reduced to an idealized system having only one degree of freedom, namely, linear deflection along one axis. Experimental equipment was so constructed that the test specimens were loaded dynamically and subjected to shear in one direction. In most machinery installations it is possible to design a rubber mounting in which all troublesome modes of vibration cause shear deformation of the rubber element. Thus the results of this investigation are applicable to installations in which more complex vibrations exist.

First phase of the investigation was to learn the behavior of typical rubber compounds when subjected to vibration simulating service conditions of machinery mountings. This involved the use of a typical mounting, the style and important dimensions of which are indicated in *Fig.* 1. Seven such mountings were made, each employing a different composition. These compositions, together with the cure and hardness, are shown in TABLE I. The chemical components and hardness values agree generally with those recommended for motor mountings by well-known suppliers.

The laboratory testing apparatus consisted essentially of a motor-driven eccentric with a connecting rod which imparted a practically simple harmonic vertical motion to

TABLE I

Compositions of Compounds Tested

Designation of compound	A	B	D	F	G	J	K
Parts by weight:							
Smoked sheet (rubber)	100	100	100	100	100	100	100
Channel carbon black	...	...	...	20	20	...	50
Gastex carbon black	...	...	...	20	20	...	...
P-33 carbon black	...	25	25	...	...	...	...
Stearic acid	1.5	1.5	1.5	2.0	2.0	1.0	3.0
Pine tar	...	...	...	2.0	2.0	...	3.0
Neozone A (phenyl-α-naphthyl-amine)	...	...	...	...	...	1.0	1.0
Neozone D (phenyl-β-naphthyl-amine)	1.0	1.0	1.0	1.5	1.5	...	...
Ureka C (benzothiazyl-thio-benzoate)	0.6	0.6	0.6	...	...	...	...
Captax (mercapto-benzothiazole)	...	...	...	1.0	1.0	1.0	1.0
Zimate (zinc dimethyl-dithio-carbamate)	...	...	...	0.1	0.1	...	...
Zinc oxide	5	5	30	5	5	5	3
Diphenyl-guanidine	...	...	...	...	...	0.1	...
Guantal (diphenyl-guanidinephthalate	0.4	0.4	0.4	...	...	...	...
Sulphur	3.0	3.0	3.0	2.5	2.5	2.0	3.0
Cure:							
Time, min.	25	25	25	20	40	40	40
Temperature, F.	307	307	307	307	307	307	307
Hardness: Durometer "A"	40	47	52	43	45	30	60

NOTE: Compound K contained 1 part Heliozone (a wax).

B (see *Fig.* 1), the amplitude of which was approximately .0015-inch, the frequency being variable from zero to 50 cycles per second. A deadweight load on *A* was variable, approximately from 10 to 100 pounds. The motions of both *A* and *B* were restricted substantially to vertical displacements by means of radius rods approximately four feet long. Two modified Geiger torsiographs, one connected to each member of the mounting, were so arranged

*Abstract of a paper presented in a session of the Aviation division at the recent A. S. M. E. annual meeting in New York.

that the vibrations of A and B were recorded simultaneously on the same paper tape. Thus, the frequency of the vibrations at any instant could be measured, as well as the amplitudes of A and B. With B stationary, it was possible to displace and suddenly release A, recording the ensuing free vibration of A. In this manner the natural frequency of the free vibration of the loaded mounting was determined. Deflections over a range of static loads were found by applying known weights and measuring the deflections recorded by the torsiographs.

It was theorized that a shear-stressed rubber mounting might behave similarly to a steel spring with a dashpot connected to its terminals to provide viscous damping. Transmissibility of a spring and dashpot system, such as that described, supporting a mass upon which is impressed a periodic force, is expressed mathematically by the following equation†:

$$\epsilon = \sqrt{\frac{1+\left(2\frac{c}{c_c}\,\frac{\omega}{\omega_n}\right)^2}{\left(1-\frac{\omega^2}{\omega_n{}^2}\right)^2+\left(2\frac{c}{c_c}\,\frac{\omega}{\omega_n}\right)^2}} \qquad (1)$$

where

ϵ = Transmissibility (ratio of transmitted to impressed periodic force)

c = Damping force per unit velocity, pounds per inch per second

c_c = Critical damping force per unit velocity, pounds per inch per second

ω = Frequency of impressed periodic force, radians per second

ω_n = Natural frequency of free vibration of machine when secured to resilient mounting, radians per second.

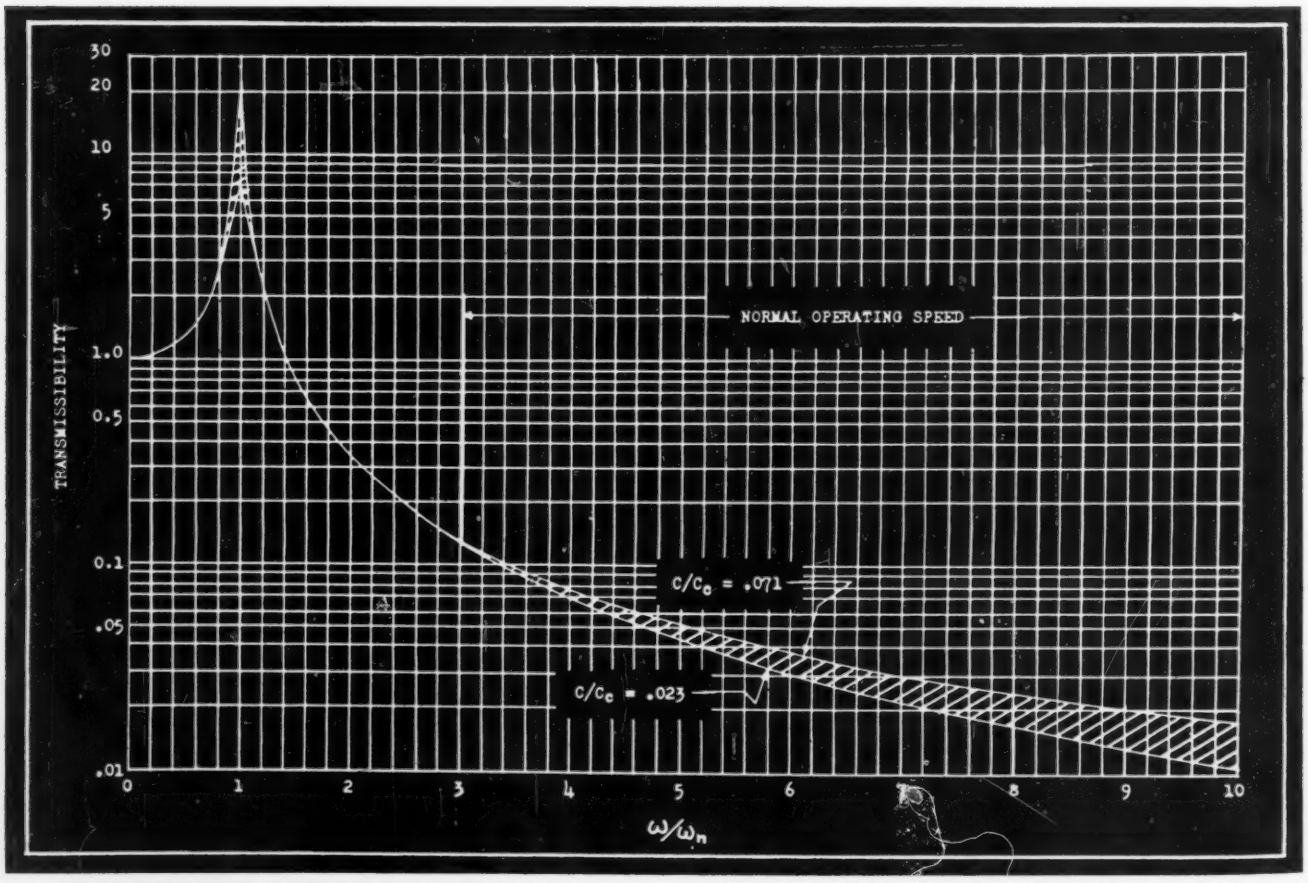
It may be shown that, for any given vibration frequency, the ratio of the amplitude of A to that of B (*Fig.* 1) is a direct measure of the transmissibility of the mounting.

Experimentally obtained values of ϵ were plotted against corresponding values of ω/ω_n. Comparing the resulting curves with similarly plotted curves derived from Equation 1, using trial values of c/c_c, it was found that very close agreement existed between experimental and theoretical curves. The apparent value of c/c_c remained practically constant for each rubber compound, being affected but little by changes in load. The compound with least damping indicated a value of c/c_c of .023, while that with most damping indicated .071.

Resilient mountings for machinery should be designed so that ω_n lies somewhere between one-third and one-tenth of the normal operating speed of the machine. If ω/ω_n is less than 3, not much advantage is to be gained from employment of a resilient mounting (see *Fig.* 2); if ω/ω_n is greater than 10, the machine usually lacks the necessary stability because of the deflection of the mounting per unit applied load becoming excessive, which follows from the necessity of making ω_n small. Observation indicates that the normal operating speed of a resiliently mounted machine is usually such that the value of ω/ω_n

†This and certain other equations which follow are derived in *Mechanical Vibrations* by J. P. Den Hartog, McGraw-Hill Book Co. Inc.

Fig. 2—Below—Transmissibility plotted against frequency ratio shows range of values experimentally obtained with vaious rubber compounds



is well within the range of 3 to 10.

Conclusions from the first phase of the investigation are presented graphically in *Fig.* 2, where the "composite transmissibility band" covers the range of values of transmissibility likely to be encountered in shear-stressed rubber machinery mountings. The boundary curves were obtained by substituting values of .023 and .071 for c/c_c in Equation 1.

Criterion for Selection Is Developed

Second phase of the investigation was the development of a criterion for the effectiveness of shear-stressed rubber compounds in isolating machinery vibration. In general there are four considerations to be taken into account in designing a resilient mounting:

(1) Upon the magnitude of the periodic force transmitted to the foundation structure, at the normal operating speed of the unit, depends the amplitude of vibration of the foundation structure, which is of primary interest when considering the comfort of personnel in the vicinity of the unit while it is operating at normal speeds.

(2) The magnitude of the maximum periodic force transmitted to the foundation structure at resonant frequencies is many times greater than the impressed periodic force and may be severe enough to cause failure of the mounting or some portion of the structure adjacent to it.

(3) The maximum amplitude of vibration of the unit at resonant frequencies is of interest with respect to the alignment of shafts between the unit and other machinery; the amount of flexing of connections to the unit, such as ducts for water, steam, oil, gasoline, or exhaust gases; and the effect of vibration upon instruments which may be mounted on the unit itself such as pressure gages, thermometers, electrical relays, governors, or other mechanisms.

(4) The same considerations pertain to the amplitude of vibration of the unit at its normal operating speed as in the case of item (3). This amplitude is much less than that at resonance, but it exists continuously while the unit is operating at normal speed.

In order to analyze the properties of rubber compounds which affect their performance in resilient mountings, approximate mathematical relations will be developed for each of the four considerations defined.

In a unit of machinery embracing a rotating member, the amplitude of the periodic force, P_0, impressed upon the mounting is usually proportional to the second power of the circular frequency. Then

$$P_0 = C\omega^2 \quad \ldots\ldots (2)$$

where C is the mass of the rotating element (slugs), multiplied by its eccentricity (feet). The eccentricity may increase somewhat with speed but, in general, this increase is negligible and for the purpose at hand C may be considered a constant. By definition

$$P_1 = P_0\epsilon \quad \ldots\ldots (3)$$

where P_1 = value of periodic force transmitted to foundation structure through resilient mounting (pounds). Substituting Equation 2 in Equation 3

$$P_1 = C\omega^2\epsilon \quad \ldots\ldots (4)$$

The vibration amplitude of the unit of machinery is expressed by the following equation

$$x_o = \frac{P_o}{k_{dy}} \frac{1}{\sqrt{\left(1-\frac{\omega^2}{\omega_n{}^2}\right)^2+\left(2\frac{c}{c_c}\frac{\omega}{\omega_n}\right)^2}} \quad \ldots\ldots (5)$$

Equations 4 and 5 are considered exact and are the basic equations upon which the criterion is developed.

In the first consideration, as an approximation let

$$\epsilon \approx (\omega_n/\omega)^2 \quad \ldots\ldots (6)$$

Substituting Equation 6 in Equation 4

$$P_1 \approx C\omega_n{}^2 \quad \ldots\ldots (7)$$

TABLE II compares the exact values of P_1 as determined by Equation 4 with the approximate values as determined by Equation 7, from which it is evident that an improvement of Equation 7 would be

$$P_1 \approx 1.26C\omega_n{}^2 \quad \ldots\ldots (8)$$

For low values of damping

$$\omega_n{}^2 = k_{dy}/m \quad \ldots\ldots (9)$$

where k_{dy} = dynamic spring constant (load per unit deflection) of resilient mounting (pounds per foot), computed from the relationship $\omega_n{}^2 = k_{dy}/m$, at any given value of load. Term ω_n is determined experimentally with a known value of m. Rubber compounds do not exhibit the same spring constant dynamically and statically as do metal springs, but appear to be stiffer under an oscillating load than under a static load. Also, m = mass

(*Continued on Page* 126)

TABLE II

Values of P_1

	Exact value of P_1 from Equation 4		Approximate value of P_1 from Equation 7
ω/ω_n	$\frac{c}{c_c}=.023$	$\frac{c}{c_c}=.071$	
3	$1.13C\omega_n{}^2$	$1.21C\omega_n{}^2$	$C\omega_n{}^2$
4	$1.09C\omega_n{}^2$	$1.22C\omega_n{}^2$	$C\omega_n{}^2$
5	$1.07C\omega_n{}^2$	$1.28C\omega_n{}^2$	$C\omega_n{}^2$
6	$1.07C\omega_n{}^2$	$1.36C\omega_n{}^2$	$C\omega_n{}^2$
7	$1.07C\omega_n{}^2$	$1.44C\omega_n{}^2$	$C\omega_n{}^2$
8	$1.08C\omega_n{}^2$	$1.54C\omega_n{}^2$	$C\omega_n{}^2$
9	$1.09C\omega_n{}^2$	$1.64C\omega_n{}^2$	$C\omega_n{}^2$
10	$1.11C\omega_n{}^2$	$1.75C\omega_n{}^2$	$C\omega_n{}^2$
Average	$1.26C\omega_n{}^2$		$C\omega_n{}^2$

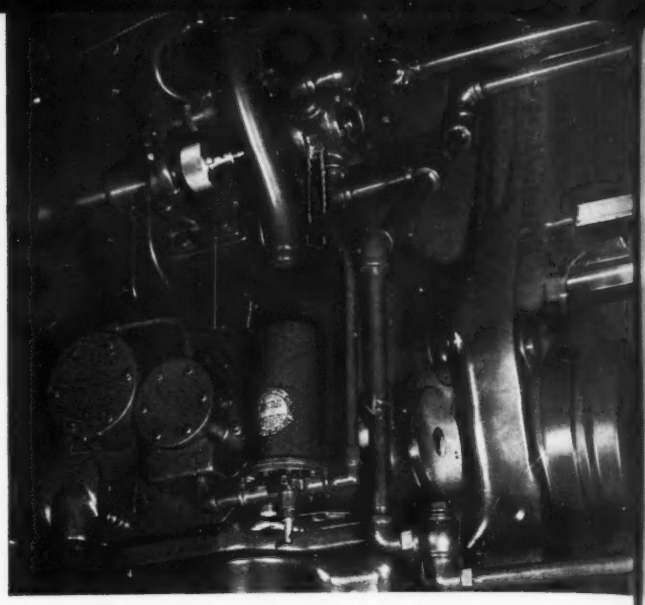


Fig. 1—Gear type pump is utilized on this turret lathe to provide sufficient pressure for flushing when deep drilling. Coupling on pump shaft may be readily disconnected when pump is not in use

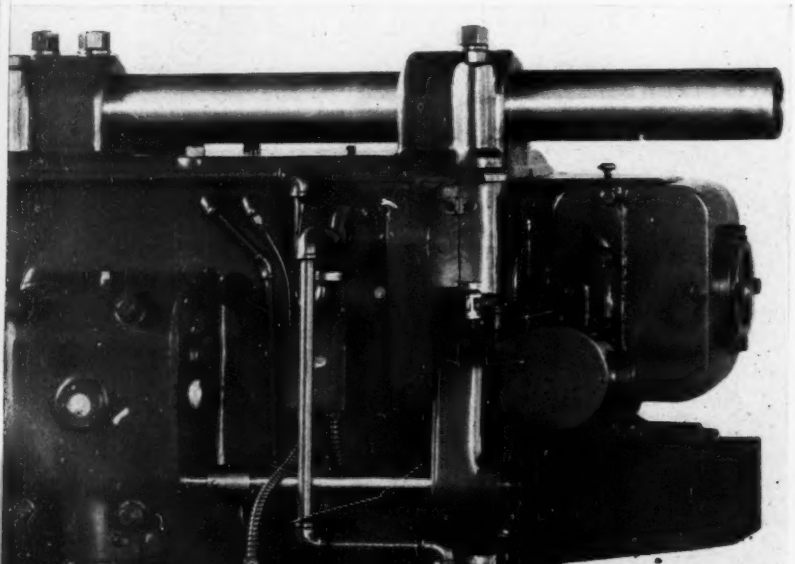
By John W. Greve

Basic Considerations in Selecting

IN SELECTING a coolant pump many factors merit consideration and should be weighed against the features of the various types available. Wherever possible this should be done while the machine is in the design stages so that provisions may be made to utilize fully the properties of the unit selected. Because maximum production is essential, proper coolant supply, both as to location and volume, is highly important. Also, adding to the timeliness of this subject is the necessary use of less experienced operators, the disadvantage resulting therefrom being offset to some extent by adequate coolant provisions.

Generally pumps should be so located that length of intake piping from the reservoir is as short as possible, as well as that of delivery piping, using a minimum number of elbows and fittings to reduce friction losses. In addition the pump and fittings preferably should not be placed over elements such as V-belts, contactors, etc., which might be affected adversely by leakage. Where possible, mounting should be such that any leakage would drain back into the reservoir. Low mounting, especially for pumps which are not self-priming, is necessary. This also reduces possible vibration by absorbing it in the heavier base casting. For built-in applications, stripped pumps offer design economies well worth utilizing. Compact arrangements are thus possible, obviating brackets, flexible couplings, etc.

Fig. 2—Positive delivery pump, designed as part of auxiliary power take-off, fits snugly against back of head on horizontal boring mill



Trends in design, necessitating that machines occupy less floor space and require less materials, reduce the size of reservoir that may be employed. This means that additional attention must be given to baffling and settling or to providing higher capacity filter units for protection of the pump against undue quantities of chips and abrasives.

Primary considerations involve selection between individually motor-driven or power take-off units in addition to whether positive delivery or centrifugal type will be utilized. Usually the type of machine and coolant requirements determine the selection. Where power take-off is readily available by V-belt or gearing, and spindle-to-pump speed is within the range of the unit, this method is often chosen. When take-off power is utilized for machines driven by multispeed motors, it is necessary to ascertain whether the pump will deliver sufficient coolant for all motor speeds. Otherwise individual motor drive is required. An additional advantage of individual drive is that it allows placement wherever most suitable.

Where constant volume or the flushing of chips with considerable pressure is required, the positive delivery pump is indicated. Typical applications are shown in *Figs.* 1 and 2. On the other hand if abrasives and the foreign materials are excessive in the coolant supply, the centrifugal pump is the type which

gives the most satisfactory service. Outstanding among this type of applications are grinders.

Dirty coolant has long been a handicap in precision grinding, honing, lapping, burnishing and polishing work. Tiny particles of metal become jammed between the finishing medium and work, causing scratches and possible spoilage. Such particles are not adequately removed by baffles and settling tank alone, filters being desirable. Filters, however, should not be expected to carry the entire load; they should be considered as an adjunct to the system, allowing the settling tank to remove the larger particles. Added life to the system and pump parts will justify the use of filters on this type of work. Further, filters often

ctingolant Pumps

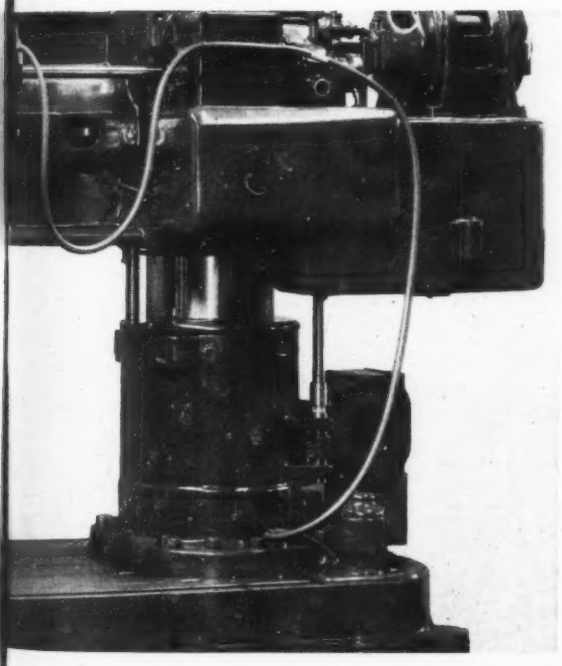


Fig. 3—Submerged type of impeller pump is flange mounted on top of reservoir in base of radial drill

allow the use of finer abrasive wheels than otherwise would be possible and, where magnetic chucks are involved, help keep the coolant parts clear of magnetized chips which might plug the ports and cause flooded bearings.

Portable type units having motorized pump and flexible tubing assembled to a standard reservoir often are applicable for building into a machine, minimizing assembly costs. Entire units may be replaced if necessary, reducing shut-down time for maintenance. In this connection pumps with the inlet port in a flange mounting are utilized when possible for direct connecting to the reservoir, obviating inlet piping and connections.

All pumps should have provisions for disconnecting when not in use. The better the provision for this, the more assurance that the operator will disconnect when machining brass or other materials not requiring coolant. When power take-off is employed, a disconnect coupling, as in *Fig.* 1, or clutch on the pump shaft is readily operable. Individual motor drives are controlled by a pushbutton station often interlocked with the main drive to preclude operation when machine is not in use.

Minimum Pipe Length Is Best

Full consideration of piping is important for best operation of a system. For single coolant nozzle, the pipe size should be at least as large as that of the pump outlet, to as near the nozzle as possible. Where more than one nozzle is required it is preferable to have the area of the main supply line increased to at least twice that of the outlets branching from it. This tends to keep friction in piping to a minimum and the pump unit performing at its maximum efficiency. Gate valves are preferably utilized because of their lowered maintenance and because of their negligible frictional resistance to fluid flow when wide open. For these reasons globe valves should not be employed. For example a 3-inch globe valve has approximately the same resistance as 50 feet of 3-inch piping.

Pressure type pumps require a relief valve to protect the parts against overload. Such a safety device usually is incorporated in design. These pumps are usually smaller in size than centrifugal ones and lend themselves readily to incorporation in the machine itself.

To determine the horsepower required for positive displacement pumps it is necessary only to multiply the weight of the liquid to be pumped per minute by the height the liquid is to be lifted and forced, dividing the result by 33,000. Corrections for friction losses from piping, fittings and viscosity are a small part

Fig. 4—Individual-drive pump of centrifugal type is conveniently located within base casting of grinder

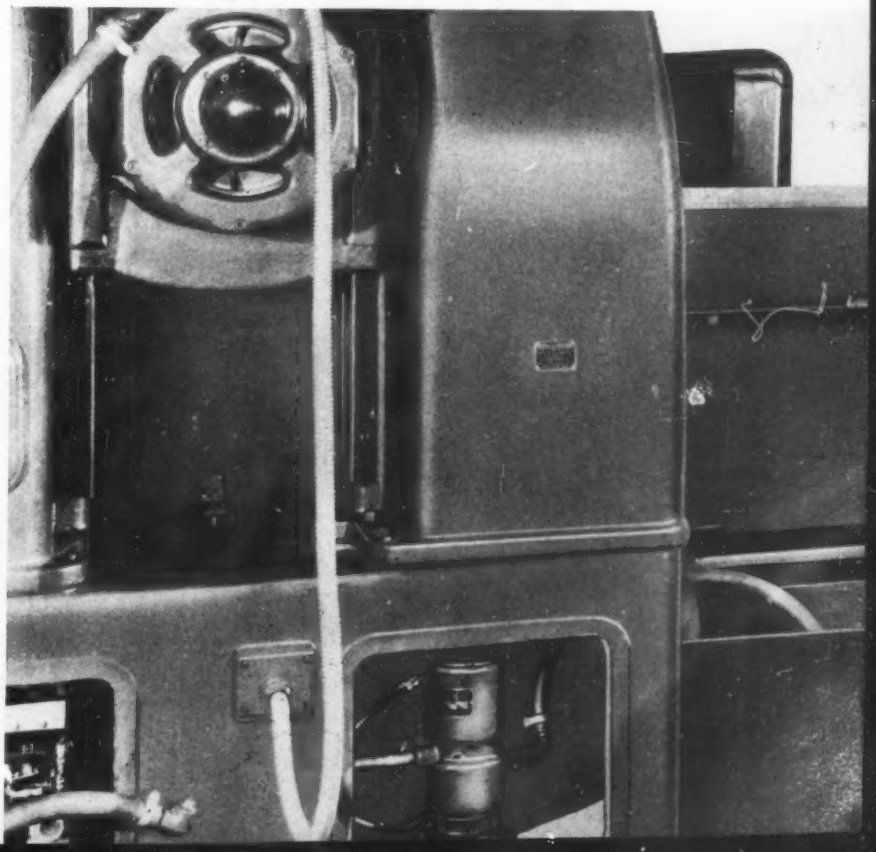


TABLE I

Equivalent Head in Feet of Water

Head Components	Water	150 SUV Oil	750 SUV Oil	1250 SUV Oil
Friction, Pipe (ft./ft.)	.25	.3	.5	1.
Friction, Fittings (ft./fitting)	1.	1.2	1.6	2.5
Head, Actual (ft.)	1.	1.2	1.4	1.8

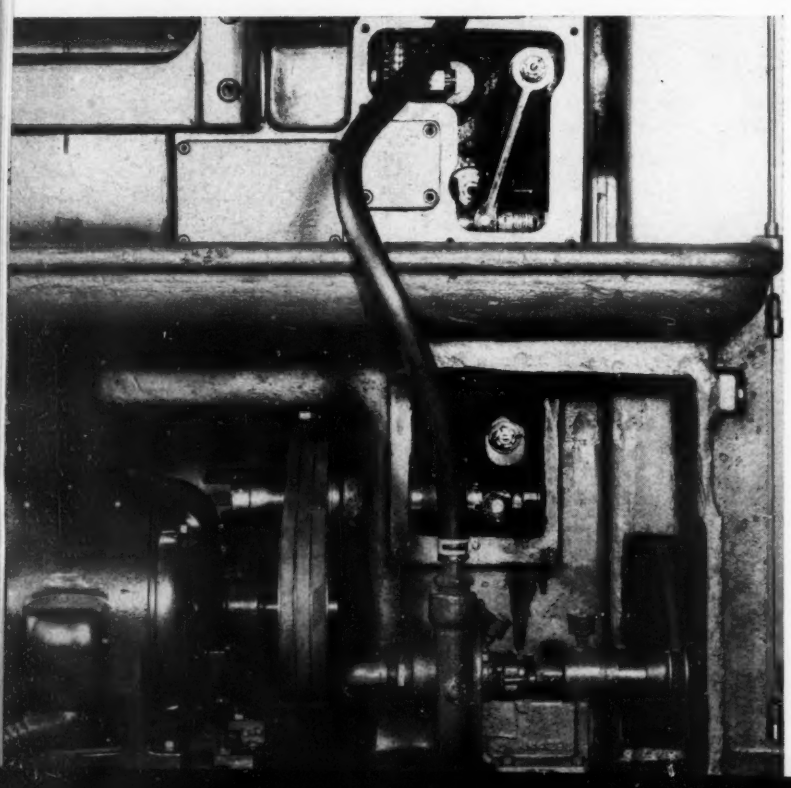
of the power requirements and are usually not necessary in determining size. Delivery of the pump is constant at a given speed, the power requirements varying with the conditions.

Centrifugal pumps frequently can be installed so that no suction or self-priming is required. Submerged types (*Fig.* 3) may be incorporated into the design of a base and, having a flange mounting and vertical motor drive, are quickly assembled. Simplicity of design involving only one rotating member—shaft with impeller at one end and motor rotor at other—is outstanding advantage. Two other styles are shown in *Figs.* 4 and 5. The former utilizes power take-off to a unit mounted within the base and the latter individual drive, similarly mounted out of harm's way but, nevertheless, highly accessible.

Delivery Is Balanced

Design of impeller blades may provide characteristics such that the power required is proportional to the delivery and inversely proportional to the head or pressure. If the motor is properly selected it is impossible to overload it, since maximum power is required at maximum delivery at zero pressure. Any increase in static head, friction head or back pressure will reduce the delivery and power requirements. Relief valves are therefore unnecessary. When pressures higher than normal are desired, high-speed motors are applied since the pressure is a function of the impeller speed.

Fig. 5—Centrifugal pump, driven by V-belt from main drive shaft, is contained within base of automatic lathe



Selection of centrifugal pump size is based upon maximum delivery requirements. If these are for short duration and the pump is individually driven, the motor may operate at slightly higher than rated capacity. This has the advantage of better power factor conditions throughout a wider operating range. Because motors are of fractional horsepower sizes this is not a marked saving from operating cost standpoint but results in desirable savings in cost of parts and in materials savings for the war program.

Delivery of a centrifugal pump is affected by the fluid handled, the operating head and the frictional losses in the system, including those resulting from piping, elbows and other fittings. Proper size of pump may be selected by checking requirements with a Weir gage, by calculation or by comparative check of requirements on similar equipment. With a Weir gage it is possible to visualize the size of the coolant stream and from this determine the gallons per minute of the stream. Calculation is the most accurate and is simple when data are available on friction losses in piping and fittings as well as viscosity of the fluid being pumped. Brief data for average conditions are listed in TABLES I and II and are particularly helpful in selecting centrifugal types. These include corrections for head from friction losses in piping and fittings for various liquid

TABLE II

Liquid Flow in Various Pipe Sizes

Head (ft.)	Pressure (psi)	Flow Through Pipe Size ⅛ (gpm)	¼ (gpm)	⅜ (gpm)	½ (gpm)	¾ (gpm)	1 (gpm)
WATER AT 60 F.							
1	.43	1.32	1.87	3.68	6.0	10.3	19.
11.5	5.	4.4	6.3	12.4	20.0	35.	64.
23.1	10.	5.9	8.6	16.5	26.8	48.	88.
34.6	15.	7.2	10.7	20.3	33.3	60.	106.5
OIL AT 150 S.U.V.							
1	.43	.96	1.4	2.8	4.4	7.9	14.
11.5	5.	3.25	4.85	9.45	15.0	26.8	47.
23.1	10.	4.3	6.3	12.5	20.0	35.3	64.3
34.6	15.	5.25	7.85	15.3	25.0	44.	78.
OIL AT 750 S.U.V.							
1	.43	.71	1.0	2.1	3.3	5.6	10.2
11.5	5.	2.4	3.5	7.0	11.	19.	34.5
23.1	10.	3.2	4.6	9.3	14.8	26.	47.5
34.6	15.	3.9	5.8	11.4	18.5	32.4	57.5
OIL AT 1250 S.U.V.							
1	.43	.6	.9	1.8	3.	5.	9.
11.5	5.	2.1	3.1	6.	9.7	16.5	30.
23.1	10.	2.7	4.1	8.	13.2	22.7	41.2
34.6	15.	3.4	5.0	9.7	16.2	28.3	50.

viscosities in Saybold universal seconds as shown in TABLE I and liquid flow in gallons per minute through various size pipes at different pressures for several liquids as listed in TABLE II. Variations in velocity have their effect upon frictional losses. However, these figures are for average conditions and are suitable for pump selection.

Cooperation of Logansport Machine, Inc. (*Fig.* 4), Pioneer Engineering & Mfg. Co. and Viking Pump Co. in the preparation of this article has been particularly helpful. Also appreciated is the assistance of the following companies: Allis-Chalmers Mfg. Co.; Bardons & Oliver, Inc. (*Fig.* 2); Brown & Sharpe Mfg. Co.; Eddington Metal Specialty Co.; Fostoria Pressed Steel Corp.; The Fulflow Specialties Co.; Goulds Pumps Inc. (*Fig.* 5); Ingersoll-Rand Co.; Geo. D. Roper Corp.; Ruthman Machinery Co. (*Fig.* 3); G. B. Spiegel Corp.; Tuthill Pump Co.; Warner & Swasey Co. (*Fig.* 1).

While maintaining the regular flow of work, this equipment can turn out prints of a Navy destroyer in one day. Without suitable paper and organization this task would overwhelm the facilities of the department

Selecting Engineering Department Papers

By H. A. Perkins
and D. H. Hunter
Forms Engineering Section
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BECAUSE of the importance of selecting proper papers for engineering department use the accompanying discussion of tests to determine the best available paper for a particular job is presented. Proper allowances should be made for changes in conditions and results desired such as life or resistance to tearing. Later articles will treat these phases as well as other media such as treated papers and cloth

PAPER is merely paper to the design engineer who draws a performance curve, a machine part or writes a specification. But paper becomes important when, after valuable time has been spent in preparing reproducible matter, it is found impossible to obtain clean, sharp, black and white prints or blueprints, which are so necessary to transmit the engineer's ideas along the proper channels.

With the tremendous demand for drafting supplies of all kinds that has been built up by the war program, it is now necessary more than ever before to have a knowledge of papers that can be used as tracing papers for countless applications which, besides conventional drafting room work, also include temporary sketch sheets, printed engineering forms, etc.

As requirements for an engineering tracing paper suitable for printed forms began to increase in volume, it became the duty of those responsible for costs and quality in the company to study the possibilities of utilizing papers that were more economical than the standard tracing papers regularly used in the drafting room.

The first step taken to achieve economy was to change to lightweight 100 per cent rag bond papers costing approximately 50 cents per pound. Use of 100 per cent rag content presupposes that a tracing paper form should have an indefinite life and be able to withstand the most severe handling. Later, cost again entered the picture and it was decided that a 50 per cent rag paper at a cost of approximately 25 cents per pound would last as long as necessary for this particular work, cutting the cost in half. Further analysis of bond tracing papers for these engineering forms developed the fact that their required life seldom, if ever, exceeded 25 years and that in many cases they were scrapped before they reached their life expectancy.

Such facts were sufficient justification to study low-rag-content papers which are suitable for use as a tracing paper, are economical in price, resist soiling, and have a high uniform value of light transmittancy (percentage of light that passes through the paper) so that quality prints could be made from pencil or ink sketches as well as from typed or printed matter.

and uniform results could be expected.

Tests were conducted therefore in which the forementioned requirements were analyzed. It should be kept in mind, however, that the conclusions apply only when the requirement standards are identical with those employed in this instance. It is not intended that these results should be interpreted as a complete solution for the selection of the proper tracing paper in every case, as other materials might well show better results where selection requirements are different.

A summary is shown in TABLE I of the preliminary tests made on 32 commercial rag-content bond papers for transmittancy and quality of prints made at different printing speeds on a black and white printing machine. This table shows there is no consistent relation between the thickness of a sheet of paper and its ability to transmit light and make good prints. Another surprising feature of the table is that high rag content does not necessarily mean that the resulting prints will be of high quality.

TABLE I

Printing Speed Tests

Test Paper (No.)	Basis Weight (lb.)	Nominal Thickness (in.)	Rag Content (%)	Type of Finish	Average Transmittancy* (%)	Satisfactory Prints at Various Printing Speeds 5 (fpm)	4½ (fpm)	4 (fpm)	3½ (fpm)	3 (fpm)
1	13	.0025	25	Dull	29½	..	..	X	X	X
2	13	.0025	25	Cockle	28	..	..	..	X	X
3	13	.0025	25	Cockle	24	..	..	..	..	..
4	13	.0028	25	Semicockle	23½	..	..	..	..	..
5	13	.0025	25	Cockle	33	X	X	X	X	X
6	13	.0025	25	Cockle	21½	..	..	..	..	..
7	13	.0025	25	Semicockle	24½	..	..	..	..	..
8	13	.0025	25	Semicockle	29	..	..	..	..	X
9	13	.0023	25	Map	29	..	..	..	..	X
10	13	.0022	25	Semicockle	39	X	X	X	X	X
11	13	.0025	25	Cockle	33	X	X	X	X	X
12	12	.0020	25	Map	36½	..	X	X	X	X
13	13	.0025	25	Map	22	..	..	..	..	..
14	13	.0025	25	Map	31½	..	..	X	X	X
15	13	.0022	25	Map	39½	X	X	X	X	X
16	13	.0026	25	Dull	23½	..	..	..	..	..
17	13	.0025	25	Cockle	36	..	X	X	X	X
18	12	.0020	75	Map	39	X	X	X	X	X
19	12	.0020	..	Map	47	..	X	X	X	X
20	9	.0015	..	Dull	87	X	X	X	X	X
21	12	.0020	100	Smooth	47	X	X	X	X	X
22	13	.0025	100	Smooth	31½	..	..	X	X	X
23	13	.0025	50	Semicockle	31½	..	X	X	X	X
24	13	.0025	25	Cockle	32½	..	..	..	X	X
25	12	.0021	100	Map	49	X	X	X	X	X
26	12	.0020	100	Map	43	X	X	X	X	X
27	12½	.0022	100	Dull	39½	X	X	X	X	X
28	13	.0028	..	Dull	31	..	..	..	X	X
29	13	.0025	100	Semicockle	36	..	..	X	X	X
30	11	.0020	65	Map	35	..	X	X	X	X
31	10	.0015	50	Smooth	57	X	X	X	X	X
32	13	.0020	25	Semicockle	39	X	X	X	X	X

* Per cent opacity Bausch & Lomb equals 100 minus per cent transmittancy.

In the tests tabulated all sheets were printed from the same printing plate with an opaque ink and, in addition, characters and identification were not only typed on the test sheets but also written with both drawing ink and lead pencil. In the production of clear prints, the more transparent a paper or cloth is, the higher is the speed at which the print machine can be run and the less dense or opaque the printed, ink or pencil fill-in can be. Tracing papers with low transparency or transmittancy result in gray or spotted prints unless they are run through the machine at slow speed. Such slow printing speeds, however, permit the printing light to "burn" through printed, ink or pencil matter unless it is totally opaque.

If India ink is applied to a paper of high or low transparency, rough or smooth surface, it flows as a liquid from the drawing pen and makes a dense line that is truly opaque. Then, regardless of the length of time the tracing is exposed to the printing light, no light can burn through and cause gray, spotty lines. Now, what happens when a tracing paper whose surface is pitty with tiny depressions or craters is printed from type whose surfaces are plane, with a viscous, semifluid ink? This ink is too thick to flow into deep depressions in the paper. Consequently, some of the printed characters are "pock marked" with white spots that are clearly visible when viewed through a magnifying glass. As a result, when white prints are made from such a printed tracing paper, many lines and characters are gray instead of solid black, resulting in less legible prints.

It is evident, therefore, that a bond tracing paper best suited for making acceptable black and white prints must have a high value of transmittancy and a certain factor of roughness, especially if it is to be printed and then filled in by pencil or typewriter. The tests outlined in TABLE I, and the decision to consider only the 12, 12½ and 13-pound papers, resulted in the elimination of 18 papers from further consideration in this study. The remaining 14 test papers were then subjected to surface roughness tests on a profilometer and further analysis of the quality of prints from pencil, ink, type and printed matter.

The profilometer used for making these surface tests is a precision instrument developed primarily to measure the finish on steel surfaces. Whereas the instrument will measure the depth of depressions in the surface of steel to as low as .5 millionths of an inch, it can be used likewise to obtain comparative values of the depth of surface indentations in sheets of paper. When a film of ink is deposited by a printing press from the normally plane surface of type onto a sheet of paper with very shallow depressions, a greater area of the printed character will be deposited than if the depressions are deep, preventing the ink from reaching and covering the bottom area of the depressions.

An examination of black and white prints, by magnifying glass, made on papers with different roughness fac-

tors, bears out the presumption that lower roughness factors result in higher quality prints, especially from printed forms such as cross section papers. The black lines on the white print appear to be solid black and there is little evidence of the white spots that show through on the tracing papers with high roughness factors and give the lines a pale gray appearance.

In TABLE II are shown roughness factor, resistance to soiling (which is inversely proportional to roughness), formation and quality of prints of the 14 papers that passed the preliminary tests successfully. Any test paper that showed a roughness factor less than 120 (average depth of depressions measured in millionths of an inch), was given a high resistance-to-soiling rating. Test sheets with uniform distribution and formation of the pulp do not have a marked cloudy appearance when viewed in front of a strong light. Uniform formation is a factor in the production of good black and white prints and must be taken into account when selecting a tracing paper. Quality of prints from pencil, ink, typed and printed matter was judged from the standpoint of excellent, satisfactory or poor and are indicated in the table by *E*, *S* or *P*, respectively. Also tabulated is approximate paper cost based upon the price of one thousand sheets of 8½ by 11-inch sheets.

TABLE II

Quality of Reproduction from Typing, Pencil, Ink and Printing

Test Paper (No.)	Thickness (in.)	Rag Content (%)	Transmittancy (%)	Roughness Factor (in.X10^{-6})	Resistance to Soiling	Formation of Sheet	Quality of Prints† Reproduced from: Typing	Pencil	Ink	Printing	Paper Cost* ($)
5	.0025	25	33	105	High	Uniform	S	S	S	E	1.50
10	.0022	25	39	110	High	Uniform	S	S	E	E	1.56
11	.0025	25	33	115	High	Uniform	S	S	E	E	1.56
12	.002	25	36½	130	Medium	Uniform	E	E	E	S	1.56
15	.0022	25	39½	100	High	Uniform	E	S	E	E	1.59
17	.0025	25	36	120	Medium	Poor	S	S	S	S	1.55
18	.002	75	39	145	Low	Uniform	E	E	E	S	2.31
19	.002	..	47	135	Medium	Fair	E	S	E	S	1.36
23	.0025	50	31½	175	Low	Fair	S	S	E	P	2.13
25	.0021	100	49	130	Medium	Poor	S	S	S	S	4.25
26	.002	100	43	100	High	Uniform	S	S	E	E	4.09
27	.0022	100	39½	150	Low	Uniform	E	E	E	P	4.09
30	.002	65	35	110	High	Fair	S	S	E	E	2.05
32	.0025	25	39	120	Medium	Fair	S	S	S	S	1.50

†Quality of Prints symbols: E, excellent; S, satisfactory; P, poor.
* Approximate cost per 1000 sheets, 8½ by 11 inches.

Selection Based Upon Point Ratings

TABLE III gives the results of the tests listing only the points of excellence as brought out in the study. Classifications include soiling resistance, sheet formation, and quality of prints. Also, lowest classification as to cost is included. By adding these points of superiority for each paper, it will be noted that paper No. 15 has a rating of 6 points which indicates it the best from the standpoints that were considered important in meeting requirements.

With respect to general requirements a satisfactory and economical bond tracing paper should meet the following specifications:

PAPER: Sized, bleached, bond, suitable for pencil and ink graphs, charts, etc., subject to reproduction by the black and white or blueprinting process

PHYSICAL PROPERTIES: Clean and as free as possible from holes, wrinkles, lumps, size spots, dirt spots, etc.

FIBER COMPOSITIONS: Not less than 25 per cent rag and the balance bleached sulphite

FORMATION: Uniform, even and free from wet-end crush marks

ERASURE: Withstand normal erasure of pencil and ink lines without excessive damage

PLY: Single ply

SIZING: Beater sized with rosin and starch and surface (tub) sized with hide glue and starch mixture in quantities sufficient to produce a hard-sized sheet

BURSTING STRENGTH: Withstand 20 pounds

TEARING STRENGTH: In the machine direction not less than 24 grams and in the cross machine direction not less than 28 grams

TENSILE STRENGTH: Per inch width in the machine direction not less than 5.75 kilograms and in the cross machine direction not less than 2.5 kilograms

FOLDING ENDURANCE: In the machine direction, not less than 600 folds and in the cross machine direction not less than 200 folds

OPACITY: Not less than 58½ per cent nor more than 60½ per cent when tested by a standard Bausch & Lomb opacimeter having a standard source of light of 32-candlepower illumination

BASIS WEIGHT: Approximately 13 pounds, based on the weight of 500 sheets, 17 by 22 inches

FLATNESS: Lie flat and not wrinkle nor curl so as to impair its use during printing and as tracing paper

THICKNESS: Thickness of paper .0025-inch plus or minus .0002-inch

FINISH: Super calendered to be of uniform thickness and have a uniform smooth finish, approximately the same on each.

TABLE III

Summary of Paper Qualities

Test Paper (No.)	High Resistance to Soiling	Uniform Formation of Paper	Quality of Prints: Typewritten (Best)	Pencil (Best)	Ink (Best)	Printed (Best)	Lowest in Cost	Points of Superiority (Total)
5	X	X	..	..	..	X	X	4
10	X	X	..	..	X	X	X	5
11	X	X	..	..	X	X	X	5
12	..	X	X	X	X	..	X	5
15	X	X	X	..	X	X	X	6
17	..	..	..	..	..	..	X	1
18	..	X	X	X	X	..	..	4
19	..	..	X	..	X	..	X	3
23	..	..	..	..	X	..	..	1
25	..	..	..	..	..	..	..	0
26	X	X	..	..	X	X	..	4
27	..	X	X	X	X	..	..	4
30	X	..	..	..	X	X	..	3
32	..	..	..	..	..	..	X	1

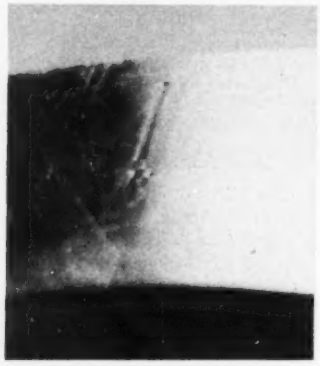


Fig. 1—Brinell mark due to pressing a straight roller without relief into a flat race

Aircraft Engine Bearings*

By Thomas Barish
Manager, Propeller Division
Engineering & Research Corp.

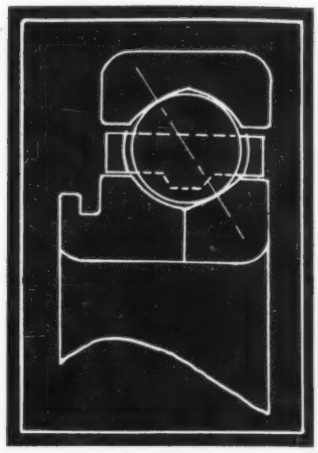


Fig. 2—Propeller thrust bearing with split inner race permits maximum number of balls without notch-filling

SPECIAL ball and roller bearings have been developed for nearly every location on aircraft power plants. Departures from the industrial standard bearings have been held to a minimum, such as reductions in width for weight saving, or large corner radii and smooth finishes for reducing stress concentrations. In some places completely special designs proved necessary with increased requirements.

Crankshaft bearings are by far the most difficult problem. They must take care of:

1. Very heavy loading; for example 10,000-pound mean and 14,000-pound maximum on the front bearing of a 1000 horsepower single-row radial engine on a bearing with 3⅞-inch bore. These loads are doubled momentarily due to gyroscopic forces which reach a peak in a tight spin.
2. Large shaft deflections due to these heavy loads combined with minimum shaft thicknesses, the worst location being at the rear where crank cheek yield and torsional vibration have their greatest effect.
3. High speeds. The present peak is about 2800 revolutions per minute on a 7½-inch bore for the center bearing of a two-row radial engine giving 6000 feet per minute, and requiring far better than standard industrial bearings.
4. Relatively high temperatures especially in this center location close to both rows of cylinders.

Ball and roller bearings are employed on crankshafts only on the radial engine, primarily because of their compactness and ease of replacement. They also afford less dependence on a continuous oil supply, less susceptibility to deflections, and in addition are valuable for the relatively slow progress of failure when it does occur. Usually the bearing will carry through to a landing and frequently remain unnoticed until major overhauls.

Radial engines were at first put into production with ball bearings on the crankshafts. The small and medium-sized engines still retain them. Notch-filled type ball bearings are used except for a few of the smallest lightly loaded jobs where conrad or nonfilling slot type are accepted as alternatives. The only common departure from standards is a reduction to "Aviation Widths" in the light or 200 series, retaining the standard ball size and cages, bores and outside diameters.

Sizes were first selected by arbitrary rules, necessarily so since the calculated loads far exceeded the ratings. Actual experience on crankshaft ball bearings used up to 2.5 times the catalog ratings for mean loads and 5 times the ratings for take-off loads and speeds.

The gathering of this experience followed the usual pattern for aviation work. Nine years ago, a No. 218 size (3.54-inch bore light series) was selected for the rear end of a 550-horsepower single-row radial engine. This same engine has been improved step-by-step to over 1100 horsepower with no change in bearing size. The first power increases eliminated the conrad type (eleven 13/16-inch balls) and specified only notch-filled type (seventeen 13/16-inch balls). That was found unsatisfactory above 850 horsepower for airline service with its extreme demands for reliability and long life (1000 hours are guaranteed and 2000 are under consideration). A square section roller bearing of the same dimensions was then introduced; and finally further power increases required improvements in these roller bearings. Investigations made in 1938 produced relatively minute, but extremely important internal changes that brought to use some of the unrealized possibilities of this type[1]. The following new features have become standard for all heavily loaded locations:

a. Edge relief of rollers required because the capacity is limited by what happens at the edge of the long, thin rectangular contact area. The high "Hertz" pressure (200,000 to 300,000 pounds per square inch) along the center of the rectangle tapers off sideways but changes abruptly at the end having no side support. Without edge relief failure occurs as a shear under this edge. This stress concentration is strik-

*Abstract of paper presented in a session of the Aviation division at the recent A. S. M. E. annual meeting in New York.
[1]All numbered references are listed at end of article.

ingly indicated when a straight roller without relief is pressed into a flat plate for checking brinelling capacity, *Fig.* 1. A small crescent-shaped permanent deflection forms under the end of each roll. A small edge relief, approximating deflections of about .0002-inch produces startling improvement in life under heavy operating loads.

b. Crowning of the outer race. The small deflection of roller bearings makes them extremely sensitive to misalignment or shaft deflections. The latter are considerable in airplane engines because shafts are of minimum size. The total yield in a straight 1-inch roller is only about .0002-inch, and a tilt of only .0002 or 1 inch or 1/10 degree would shift the contact entirely away from one end. Even more serious, the loaded end tends to drag and swerves the roller to one side. Crowning the outer race track largely eliminates these effects and without loss of capacity because the surface pressure of the concave outer can still be kept below that of the convex inner. Crowning the outer race introduced serious production problems which, however, have been satisfactorily solved. Incidentally, the crowned race improves the load distribution among all the rollers as well as along the roller length because of increased deflections.

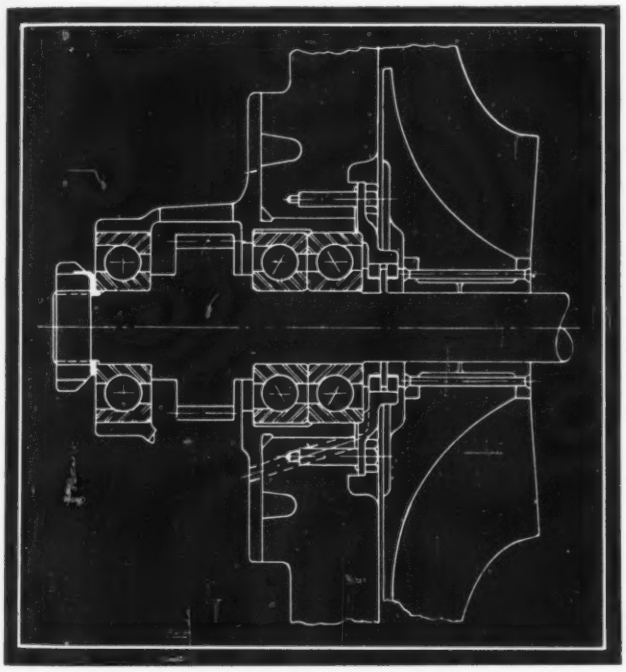


Fig. 3—Typical supercharger bearing layout for a shaft running 36,000 revolutions per minute

c. A new one-piece retainer design with square broached holes permitting 10 to 20 per cent more rollers, primarily designed to eliminate the rivets which have always been a hazard. The design permits complete disassembly of the bearing for overhaul inspection, a feature especially valued by the air lines.

d. Control of the oil flow to the critical points in the bearing.

These design features produced two to three times the life, and a marked reduction in operating temperatures, also in noise. Higher permissible operating speeds are indicated. In recent tests a No. 219 size bearing (3.9-inch bore light series) ran 960 hours at 9000 pounds load and 6000 revolutions per minute. The load-carrying possibilities of these improved rollers have not been exhausted yet especially at higher speeds. Probably much of the unusually high load capacity at top speeds results from the low coefficient of friction and low heat generation[2].

Frequently all the inner rings of any one size are made interchangeable for replacement of separate parts. This involves extremely close production control and even then requires wider tolerances on internal looseness.

Much effort has been expended on the subject of internal looseness and fits. Shaft galling due to high unit pressures with relatively narrow bearings, has been largely cured by increasing press fits to .0005 to .0007 minimum. Additional internal looseness is then needed as the maximum press fits often reach .0025-inch and inner races expand correspondingly. Research still continues on internal fits since theory indicates a marked drop in roller bearing capacity for looser bearings. Also certain types of engine vibration can be helped by reducing looseness both internally and around the outside diameter. Experimental checking on this is still in progress.

High operating temperatures in bearings near the cylinders may produce slight softening of the steel and a small permanent growth in standard bearing steel, SAE 52100. Judging from this growth the temperatures often reach 350 degrees Fahr. A new steel-drawing technique ("stabilizing") corrected this condition by the use of much longer soaking. New alloys are on test to permit higher operating temperatures without much loss of hardness or growth.

These roller bearings also serve usefully in gear boxes with in-line engines. Several of the late U. S. engines follow English practice of eliminating inner races and having the rollers ride directly on the pinion extensions or gear shaft, thus eliminating fits, galling, and nuts for clamping.

Propeller Thrust and Radial Loads

All but the smallest airplane engines regularly employ the single-row radial ball bearing for the propeller thrust and radial loads. The major departures from standard are in reduced "Aviation Widths". The notch-filled and conrad type ball bearings remain standard in all of the medium size group. With the advent of constant-speed controllable propellers, the larger engines found it necessary to use only the conrad type because of a great increase in takeoff thrust.

(*Continued on Page* 138)

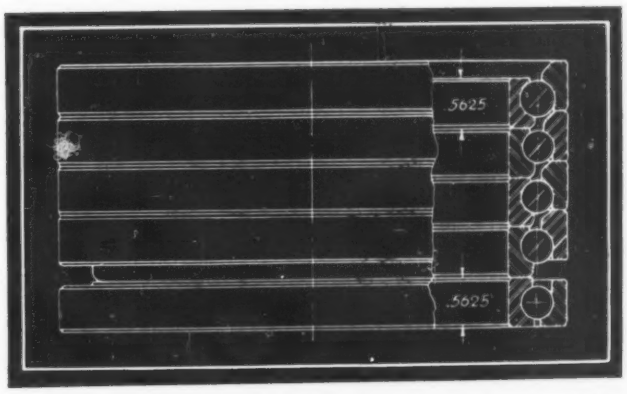


Fig. 4—Offset stacked bearing for blade of controllable pitch propeller provides high thrust capacity due to proper division of load

How Industrial Trucs Current Needs

Fig. 1—Designed for utility, industrial truck has increased maneuverability and capacity by carrying load on the fork lift close to fulcrum point

COMPACT, sturdy and versatile, designed for materials handling in industrial plants, ship loading, etc., where operation with heavy loads in close quarters is required, the Towmotor fork type truck illustrated in *Fig.* 1 involves design problems which are peculiarly individualistic. Automotive features such as those employed in highway trucks or farm tractors do not apply to this unit. Short wheel base and counterbalanced weight are primary considerations in providing maneuverability and capacity. Power plant is small compared to the load capacity because, in the close quarters for which the machine is designed to operate, speeds higher than 10 miles per hour would be excessive. For this model a 40-horsepower gasoline engine handles loads up to 10,000 pounds.

Load Is Unsprung Weight

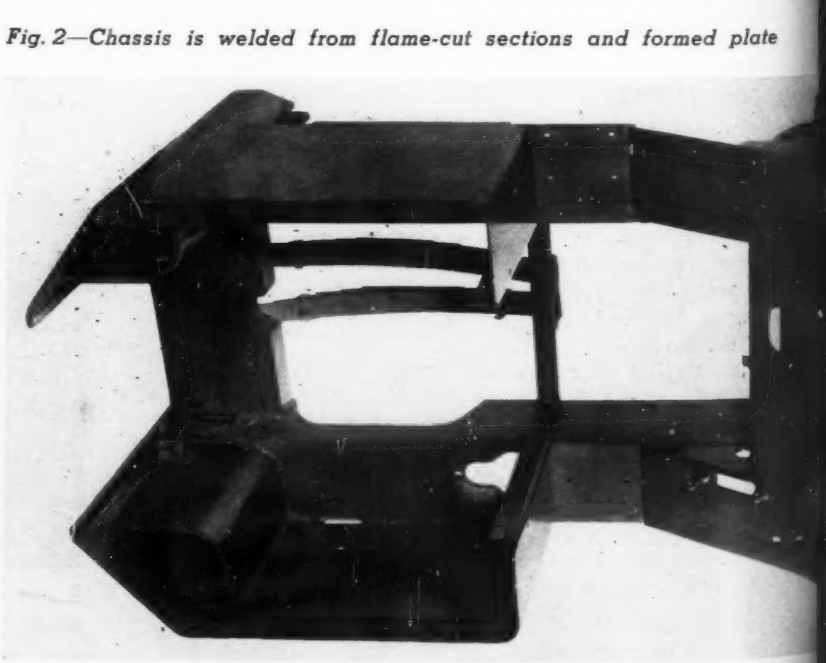
Load and front end of chassis are unsprung weights, necessitated by the nature of work performed. Similarly pneumatic tires are not employed, solid rubber meeting the requirements. Pneumatic tires if used would necessarily be so large that maneuverability and other design features would be sacrificed.

Being among the highest rated, from viewpoint of priorities, industrial type trucks are allotted materials in the quantities needed for maximum production. Largely utilizing formed plate, standard shapes, forgings and castings there are, however, quantities of copper and high alloys also required, the former involving radiator fins, hydraulic tubing, etc., and the latter largely gearing and shafting. Alternatives are being studied carefully for the eventuality of substitution and include such parts as strip steel radiator fins, less critical alloys for gears, etc., and plastic tubing for the hydraulic system.

Virtually all-welded construction from flame-cut and formed sheet and standard sections the frame provides maximum rigidity and load-carrying capacity consistent with economy, fast production and material conservation. The construction is shown in *Fig.* 2. Pockets in the rear sides add rigidity and are used for ballast as required. Portions cut out from the main frame members are utilized as brackets, etc., in such a war that there is little unused material remaining after fabrication.

Power plant is located under operator's seat with transmission end forward. Engine is mounted to chassis on rubber cushions front

Fig. 2—Chassis is welded from flame-cut sections and formed plate



Truesign Meets

and rear to isolate engine vibration and also reduce any shock to the engine parts which might be transmitted by the chassis. Clutch is a single disk, dry type of heavy-duty capacity not primarily for power transmission requirements but because frequent operation must allow for heat dissipation. Transmission is a special design for short coupling and vertical step down, connecting through a universal to a stub drive shaft.

Design of transmission and its housing is indicated in the cross-sectional view, *Fig.* 3. Underside view, *Fig.* 4 shows close-couple features of transmission. Two shifting forks provide for high and low, forward and reverse gear shifts on spline shafts. Because the gear shifts are so arranged, there is no need for mechanical interlocking, each shifting fork passing through neutral. Spur gears instead of helical are sufficient for quiet operation at the comparatively slow speeds of the truck, further refinement being unnecessary from an economical standpoint.

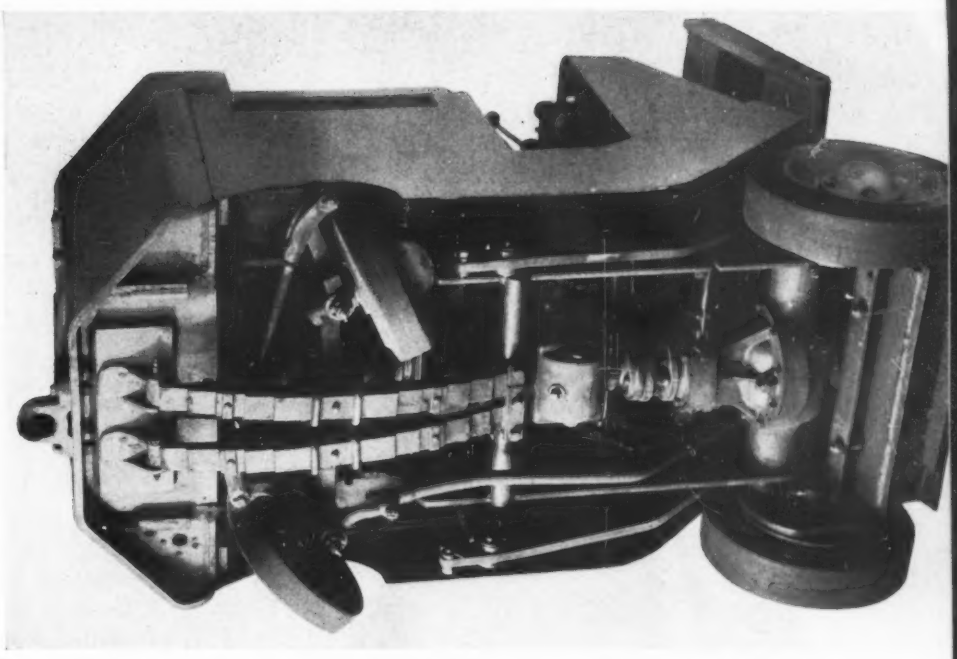


Fig. 4—Underside view shows compact, sturdy design

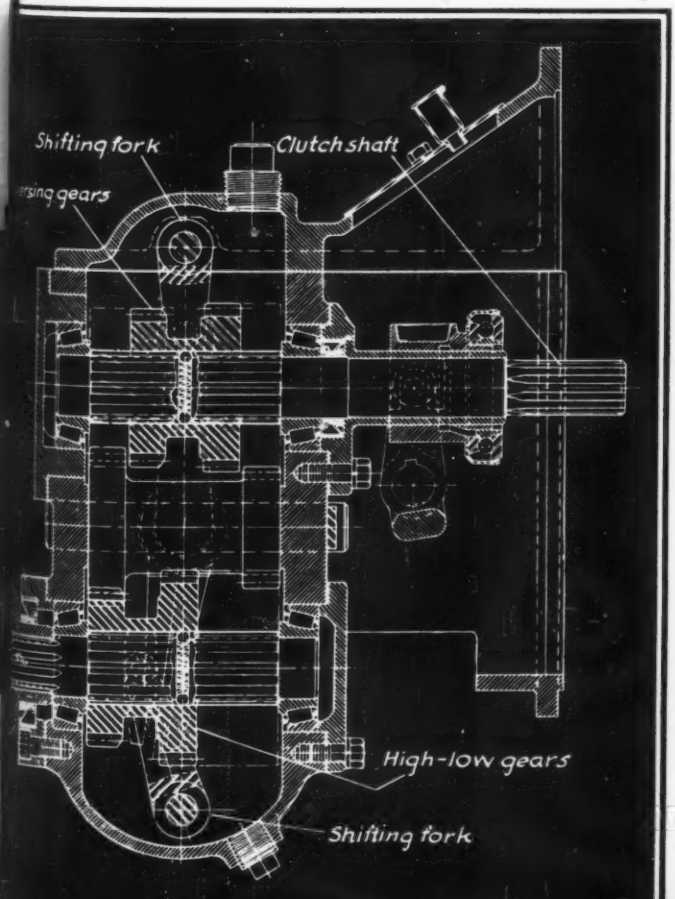


Fig. 3—Section through transmission indicates gearshif arrangement. Vertical design provides both for close coupling and clearance under engine for steering

Particularly interesting is the drive arrangement to the wheels. The short, high transmission gives space for the use of an internal gear drive with differential to the rear or engine side of the axle center line. This arrangement, in turn, permits placing the lifting mechanism between the wheels, supported on the cross member shown in *Fig.* 6, thus keeping the load as close as possible to the axle center which is the balance point.

Differential gearing is standard. The axles or jackshafts, however, terminate with spur gears instead of the wheel hub, *Fig.* 6. These drive internal gears on the inside of the wheel rims, allowing two marked design advantages: Final gear reduction is at the wheel rim to reduce the torque on the drive members so that lighter parts operating at higher speeds may be used. Also, sufficient clearance between floor and differential housing is provided by the offset, thus allowing the use of smaller wheels which greatly increases the compactness of the machine and reduces the moment of the overhanging load.

Steering Effort Is Small

As mentioned, the vertical arrangement of the transmission provides sufficient clearance under the power plant for spring suspension and steering clearances for the rear wheels. Steering axle is supported from two semi-elliptic springs in such a way that most of the power plant as well as the operator's seat is cushioned as sprung weight, greatly reducing the shock loads on the more delicate mechanisms included in the power plant assembly. Springs are close-spaced longitudinally in V-like arrangement to give an extreme turning radius to the wheels, allowing pivoting about a point only eight inches beyond the rear wheel even though underhanging suspension is employed and wheels are on a short axle, *Figs.* 2 and 4. This close spacing of the springs absorbs axle tilt resulting from travel

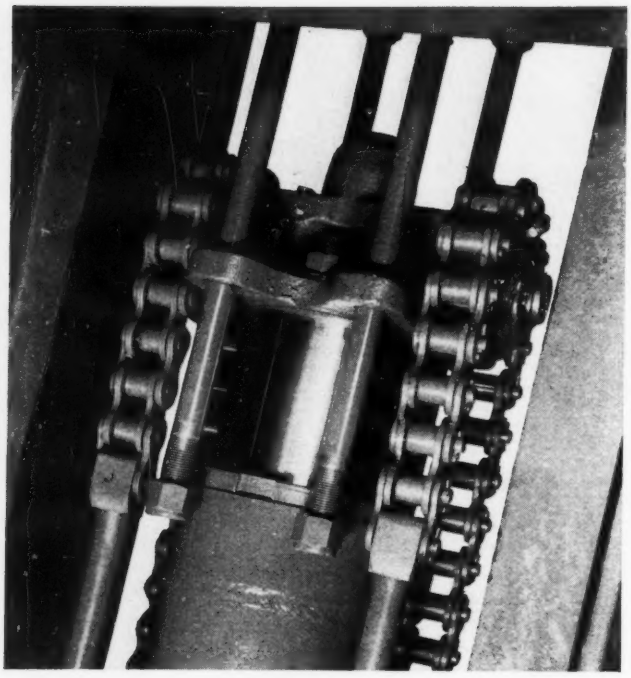


Fig. 5—Hydraulic ram raises telescoping guide on piston head. fork assembly lifting on chains with one end affixed to chassis to give lift double that of piston movement

on uneven floors without transmitting to the chassis any tendency to twist. Springs are bushed at rear end in brackets welded to the rear cross member of the frame and assembled to a cross bar welded into flame cut recesses near the center of the chassis. Because the drive wheel spindles, constituting a fulcrum, support the load, steering mechanism is relatively light and steering effort is small, becoming easier with increased loadings.

Hydraulic system for lifting and tilting is supplied from a gear type pump driven direct from the front end of the engine crankshaft. Pump is close coupled with a flange type mounting bolted to the timing gear housing. Previous designs employed a chain take-off with the pump mounted on the chassis. Present method has the advantages of simpler construction and fewer parts as well as of absorbing pump vibrations through the engine mass and mountings. Flexible hose sections however, are needed, for the pump which are relatively simple compared with the alternative mounting requirements.

Hydraulics Operate Fork Movements

Both hydraulic cylinders and arms for the fork-tilting mechanism are visible in the underside view in *Fig.* 4. These are operator-controlled from a lever located to the right of the steering wheel. Cylinders are single acting because the overhanging weight of the fork causes the hydraulic fluid to return to the reservoir when the system is de-energized. At the end of each arm a rod is pinned which, acting through compression springs on the upper side of the chassis, assists in return of the piston and keeps a loading on the piston linkage obviating play due to looseness or wear.

Vertical lift cylinder end is shown in detail in *Fig.* 5. Energized similarly through a control valve near the steering wheel, the fork lift movement is increased to double that of the piston by a chain arrangement. One end of each chain is fixed to a rod bolted to the chassis, the other being affixed to the fork. The slide, however,

(*Concluded on Page* 112)

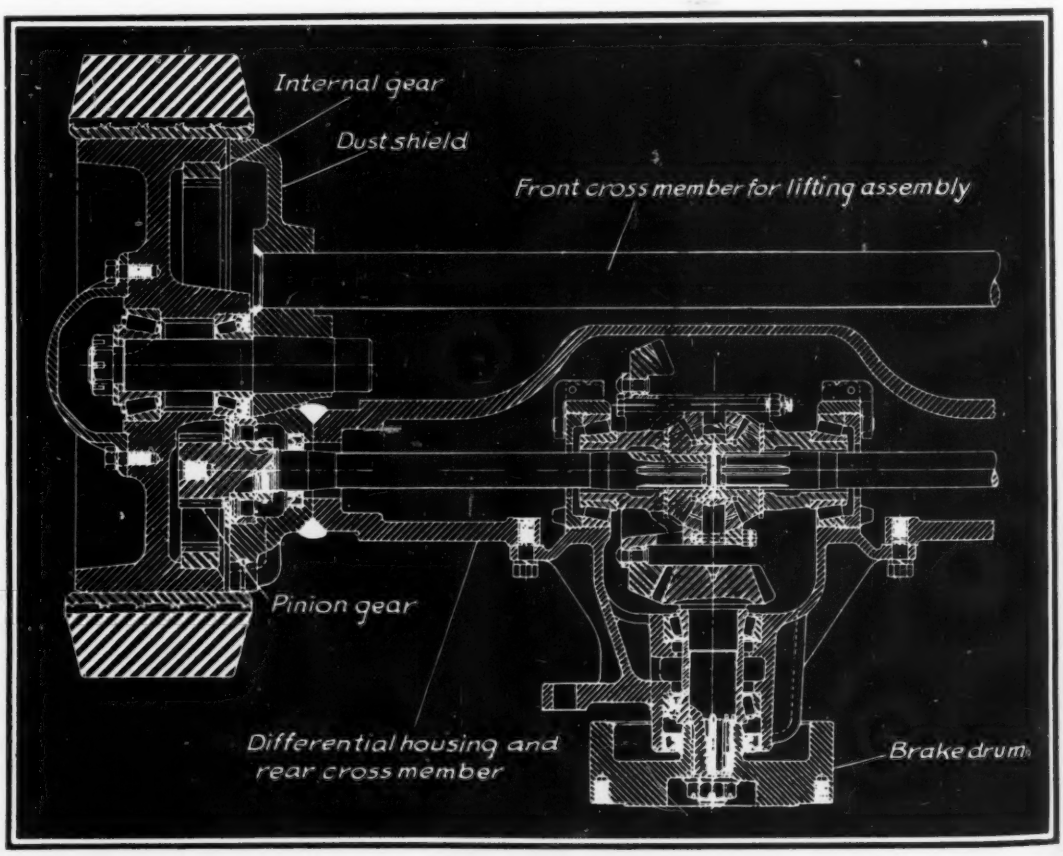


Fig. 6 — Front-wheel drive utilizes internal gear on rim of wheel driven by pinion gear on jackshaft from conventional differential. Housing is integral with chassis

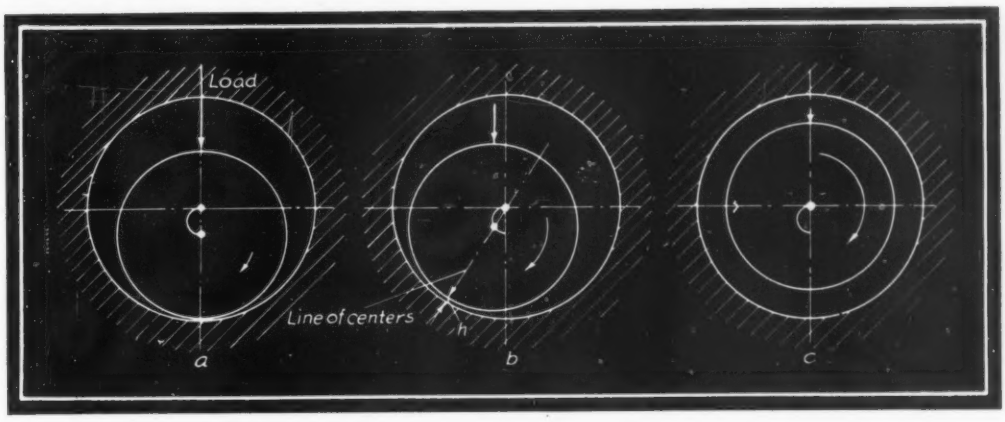


Fig. 1—Shows relative positions of journal and bearing for (a) high load and low speed, (b) intermediate load and speed, (c) low load and high speed

Bearing Design as Affected by Lubrication Theory

By Arthur H. Korn
Chief Engineer
Holly Pneumatic Systems, Inc.

HYDRODYNAMIC theory of bearing lubrication shows that a load-carrying sliding surface need not touch its supporting counterpart. The sliding surfaces can be completely separated by lubricant, provided a fluid wedge is maintained between the surfaces.

This wedge is present in any sleeve bearing as long as the bearing diameter is slightly larger than the shaft diameter. If the load imposed upon the rotating journal is extreme, or the rotating speed close to zero, the journal takes a position relative to the bearing and the line of the load as indicated in *Fig.* 1*a*. If, on the other hand, the velocity is extreme or the load approaches zero an oil film is built up which forces the journal into the concentric position, *Fig.* 1*c*. For intermediate conditions of load and velocity the position of the shaft must be somewhere between the extremes, as in *Fig.* 1*b*.

Of major importance in bearing design is the determination of the oil film thickness, h, at the point where the wedge-like gap between bearing and shaft is narrowest. Determination of the exact path described by the shaft center under varying conditions between the two extremes and relative to the line on which the load is acting has been the object of mathematical investigation. It has been found that the center follows approximately a semicircle as indicated. This has also been verified fairly well by experiments for the type of bearing under consideration.

Securing strictly fluid film lubrication is primarily a question of selecting the proper bearing clearance. Using the notation:

D = Diameter* of bearing, inches
d = Diameter * of shaft, inches
Δ = Roughness of bearing, inches
δ = Roughness of shaft, inches
l = Subscript indicating largest diameter or upper limit of tolerance
s = Subscript indicating smallest diameter or lower limit of tolerance
B = Width of bearing, inches
h = Oil film thickness on line of bearing and shaft centers, inches
f = Difference in oil film thickness due to a deflection of the shaft, inches
p = Unit pressure on projected bearing area, pounds per square inch
n = Velocity in revolutions per minute
μ = Absolute viscosity of lubricant in Reyns, pound-seconds per square inch.

the relative bearing clearance is given by

$$\frac{D-d+2(\Delta+\delta)}{d}=2.8\times10^{-6}\left(\frac{\mu n}{cp}\right)^{10/3}\left(\frac{d}{h}\right)^{17/3} \quad \ldots(1)$$

where c is a correction factor having the value

*Actual diameters as determined by micrometer measurements.

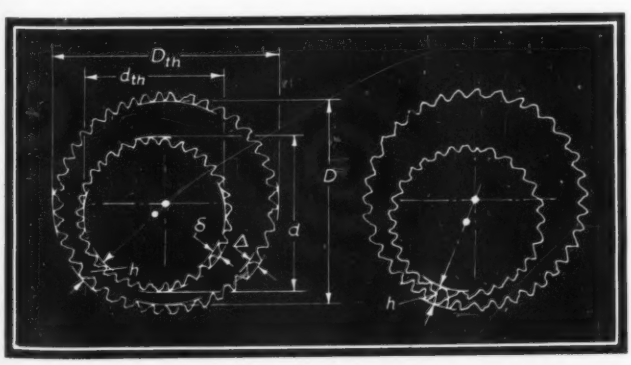


Fig. 2—Diagram at right shows boundary conditions, the peaks of the surface roughnesses beginning to touch each other. At left complete fluid film exists

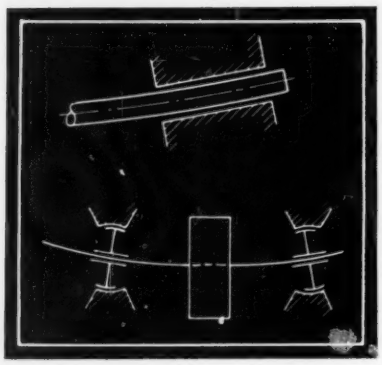


Fig. 3—Self-aligning bearings ensure approximate parallelism, except for curvature of shaft within the bearing, as shown in top view

$$c=1+2\left(\frac{D}{B}\right) \quad \ldots\ldots (2)$$

Based on hydrodynamic lubrication theory, these equations are the result of tests†. Agreement with purely theoretical analysis is reasonably close for values of $2h/(D-d)$ lying between .3 and .8. The original calculations were made for a bearing of infinite width (no side leakage). To make the equation applicable to bearings of finite width in which side leakage would cause a reduction in capacity the correction factor c is used. For bearings widths of unusual proportions this factor should be applied with caution.

The idealized geometrical solids which form the basis of the mathematical analysis do not exist in reality. Even cylinders of the most refined surface finish have an unevenness or roughnes of such a magnitude in comparison with the oil film thickness that it cannot be neglected. The surface roughnesses shown in *Fig.* 2 are noted $\triangle$ and δ for bearing and shaft respectively. If complete separation of the sliding surfaces, which are presumed to be parallel, is to be assured the oil film thickness must be greater than the sum of the roughnesses.

Oil film thickness, however, may not be the same over the entire bearing width but may vary between a maximum at one end and a minimum at the other end, or the film thickness may be greater at the ends than in between or vice versa. The difference in film thickness, which may be denoted by f, is generally due to a deflection of the shaft and can be determined with accuracy for different conditions of loading and various shaft proportions using the well known formulas for beam deflection. It is then permissible to use the mean film thickness in Equation 1 provided the misalignment is not excessive. In order to achieve complete separation of the sliding surfaces at the point where the deflected shaft would touch the bearing first, the mean oil film thickness used for calculating purposes must be greater than the sum of the surface roughnesses plus one half of the deflection, or

$$h\geqq\Delta+\delta+\frac{1}{2}f \quad \ldots\ldots (3)$$

It should be noted that in *Fig.* 2 distinction is made between the actual diameters, D and d, which can be measured directly and the theoretical diameters, D_{th} and d_{th}. All equations of the hydrodynamic theory of lubrication derived by mathematical analysis refer to the theoretical clearance, $D_{th}-d_{th}$, while here the actual clearance, $D-d$, is used.

Eliminating the thickness, h, from Equations 1 and 3:

$$\frac{D-d+2(\Delta+\delta)}{d}\leqq$$

$$2.8\times10^{-6}\left(\frac{\mu n}{cp}\right)^{10/3}\left(\frac{d}{\Delta+\delta+\frac{1}{2}f}\right)^{17/3} \quad \ldots\ldots (4)$$

Also, it has been found that if the load on a bearing is comparatively light so that the shaft runs close to the concentric position, *Fig.* 1*c*, the shaft has a tendency to become unstable and is subject to vibrations. The relative film thickness therefore should not exceed the value:

$$\frac{h}{D-d+2(\Delta+\delta)}\leqq.35 \quad \ldots\ldots (5)$$

With this equation the film thickness can be eliminated from Equation 1, with the result:

$$\frac{D-d+2(\Delta+\delta)}{d}\geqq.36\sqrt{\frac{\mu n}{cp}} \quad \ldots\ldots (6)$$

Equations 4 and 6 show that any clearance may be chosen between two limiting values. At the upper extreme, Equation 4, the sliding surfaces begin to touch each other. Near the lower extreme, Equation 6, the shaft has a tendency to become unstable. In order to obtain maximum film thickness at the point where shaft and bearing approach each other closest, the relative film thickness must have a definite value $h/(D-d+2\triangle+2\delta)=.325$. With this value substituted, Equation 1 becomes:

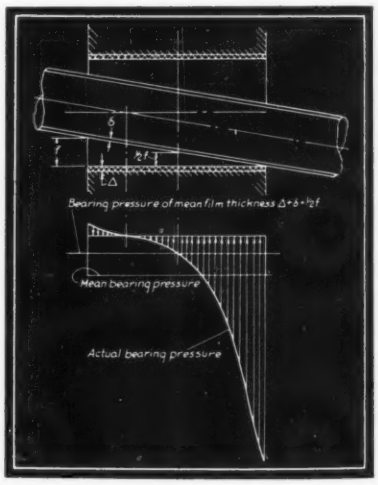


Fig. 4—Pressure distribution when shaft deflects, assuming bearing is sealed against side leakage

$$\frac{D-d+2(\Delta+\delta)}{d}=.38\sqrt{\frac{\mu n}{cp}} \quad \ldots\ldots (7)$$

In case the range of values from which choice can be made is great enough, it is possible to select a clearance for which the fluid friction produced in the film will be a minimum. This happens when $h/(D-d+2\triangle+2\delta)=.25$. With this value substituted, Equation 1 becomes:

†A. Rumpf—V. D. I. *Forschungsheft*, No. 393, 1938.

$$\frac{D-d+2(\Delta+\delta)}{d}=.48\sqrt{\frac{\mu n}{cp}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

If the bearing pressure increases or the speed diminishes, the range of permissible clearances narrows until finally Equations 4 and 6 yield equal values. Then:

$$D-d=.87(\Delta+\delta)+1.44f \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Equation 9 represents the clearance a bearing should be given if load, deflection, roughness, etc., are such that semifluid friction occurs, contact of the solid surfaces being required in order to help sustain the load.

Shaft and bearing diameter tolerances must also be considered. If the largest diameter or upper limit of the tolerance of either be noted by subscript l and the smallest diameter or lower limit be marked by subscript s, maximum bearing clearance is $D_l—d_s$ and minimum clearance $D_s—d_l$. Since Equations 4 and 6 must hold true for both, it is possible to write:

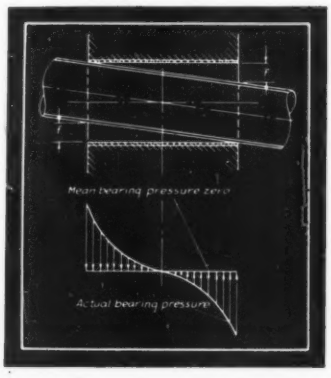


Fig. 5—Load capacity of this bearing is zero due to excessive deflection. Pressure distribution is for no side leakage

$$2.8\times10^{-6}\left(\frac{\mu n}{cp}\right)^{10/3}\left(\frac{d}{\Delta+\delta+\frac{1}{2}f}\right)^{17/3}\geqq$$

$$\frac{D_l-d_s+2(\Delta+\delta)}{d}>\frac{D_s-d_l+2(\Delta+\delta)}{d}\geqq.36\sqrt{\frac{\mu n}{cp}} \quad .. (10)$$

In view of the fact that clearances are a function of the surface roughnesses, the machine designer must have a knowledge of the magnitude to which the surface roughnesses can be reduced by the various machining operations and shop methods he calls for on his drawings.

Having the important information needed to determine the clearance of thick-film lubricated bearings, discussion of a few essentials of bearing design is in order.

It is desirable to keep shaft and bearing as nearly parallel as possible. Since a shaft deflects under load this can be obtained only through the use of self-aligning bearings as shown schematically in *Fig.* 3. Even then perfect parallelism is not assured, for a deflected shaft has a definite curvature within the bearing, as indicated in the enlargement, *Fig.* 3.

Space limitations as well as higher cost sometimes prohibit the use of self-aligning bearings. The deflection of a shaft in a rigid bearing is often so great that with the expedient of using the mean film thickness the terms of Equations 4, 6 and 10 cannot be met. Actually, however, the load-carrying capacity of a bearing with a considerably deflected shaft usually is far greater than is indicated by Equation 4 with the mean film thickness substituted. This is diagrammatically shown in *Fig.* 4 for a bearing sealed against side leakage. However, the clearances given by Equation 9 are approximately correct even in cases of serious misalignment. It should be noted that the load carried by the bearing in *Fig.* 4 is partly negative. If the bearing is given no clearance beyond the amount of the deflection as in *Fig.* 5 where $D—d=f$ the load carrying capacity of the bearing will be zero, regardless of the amount of side leakage.

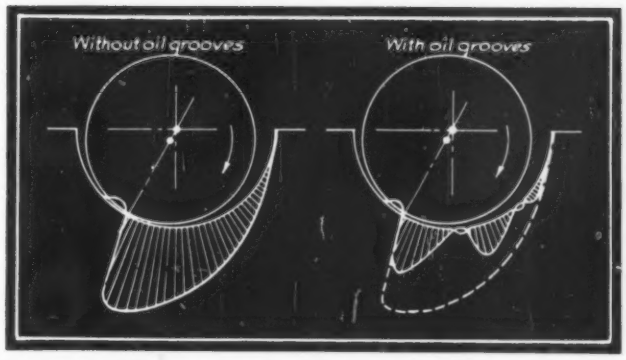
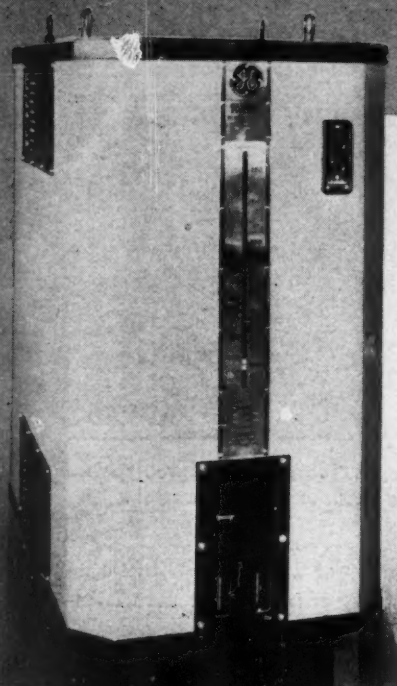


Fig. 6—Polar diagram of oil pressure in 180-degree partial bearings with and without oil grooves

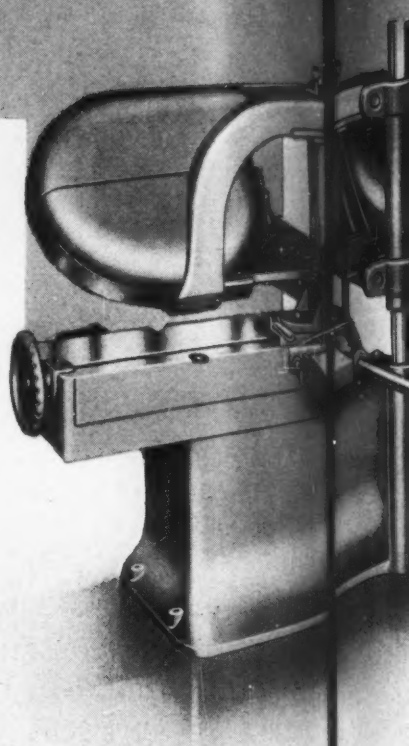
Advent of the hydrodynamic theory of bearing lubrication has revised engineers' views on the function of oil grooves in bearings. Since the solid surfaces do not touch each other the bearing load has to be sustained by high pressure within the oil film itself, an oil pressure which can be built up only where a wedge is present. The pressure starts with zero at the point where clearance between bearing and shaft is greatest and gradually rises to a maximum to drop off sharply to zero again at the point of minimum clearance and even slightly below zero behind that point as diagrammatically shown for a partial bearing in *Fig.* 6*a*. If the wedge is interrupted by an oil groove the pressure which has been built up to that point suddenly is relieved and drops back to zero, from which it is built up anew to the next interruption, *Fig.* 6*b*. The load carrying capacity of a bearing is thus severely lowered by oil grooves in the pressure area.

The equations of hydrodynamic lubrication are characterized by the value $\mu n/cp$. As long as this value remains constant there can be no change in either oil film thickness or heat generation regardless of variations of load p and speed n. Before the advent of the hydrodynamic theory the product pv, where v=velocity of the sliding surface, was thought to be a governing factor in bearing design. Assuming a constant coefficient of friction the product pv is directly indicative of the heat generated in a bearing. Hence it was reasoned this value ought to be more or less constant, so as to keep the bearing temperature within reasonable limits. This is fallacious reasoning which overemphasizes the generation of heat.

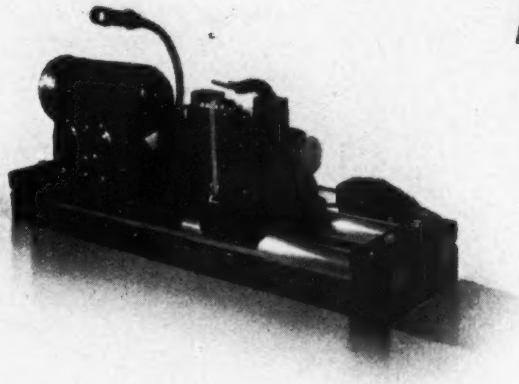
If the old assumption, pv=constant, were correct then a great load could be imposed on a slow running shaft. Actually, because an oil film can be built up and maintained only by dynamic action, a nearly stationary shaft can carry no load.



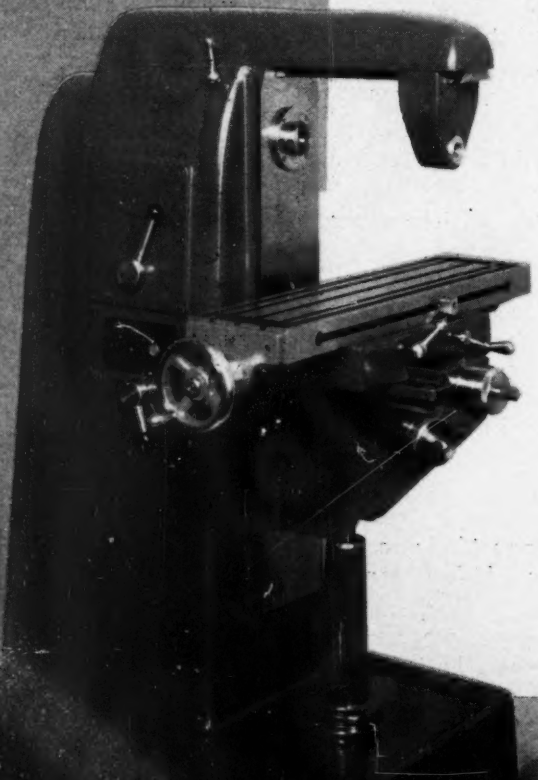
Left—Built-in primary control simplifies wiring and promotes compactness in the new G. E. transformers for unionmelt welding. Capacitors, also built in, improve voltage regulation of the power feeders, thus aiding uniform welding. Motor-operated remote control of welding current permits operator to make adjustments without leaving work



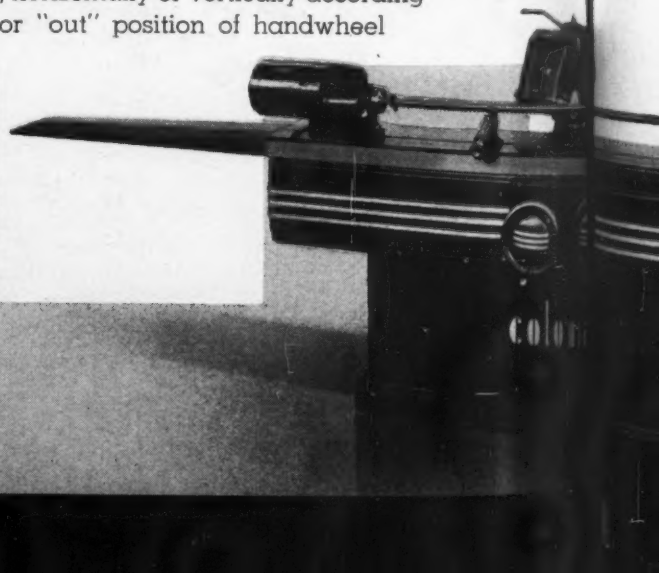
Right—Through a single reading of the trace on the screen of a cathode ray tube, the Annis dynograph indicates both the amount and position of unbalance in rotating parts. The scale may be calibrated in practical units of correction such as inches of solder or depth of a drilled hole of specified diameter



Below—Meeting the demand for a small machine capable of accurate work on a production basis, the Douglas plain miller uses a two-speed change gear in series with a four-speed V-belt cone-pulley drive to give eight spindle speeds. Spindles, shafts and lead screws are mounted in antifriction bearings



Below—Accommodating either round or flat broaches, the Colonial broach sharpening machine has a table traveling on one flat and one V-shaped way. Right handwheel controls table movement, left handwheel actuates grinding wheel head, horizontally or vertically according to "in" or "out" position of handwheel



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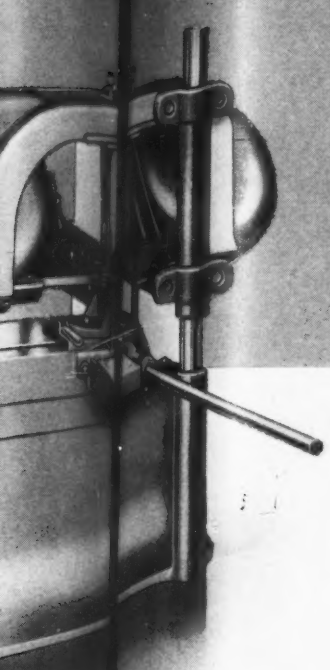
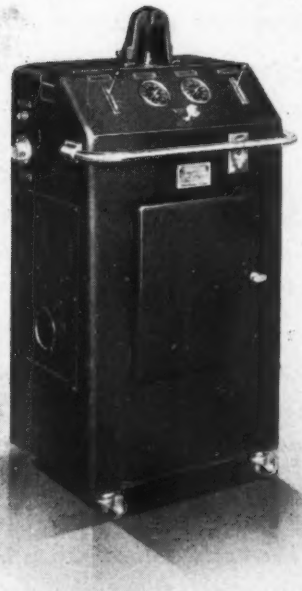
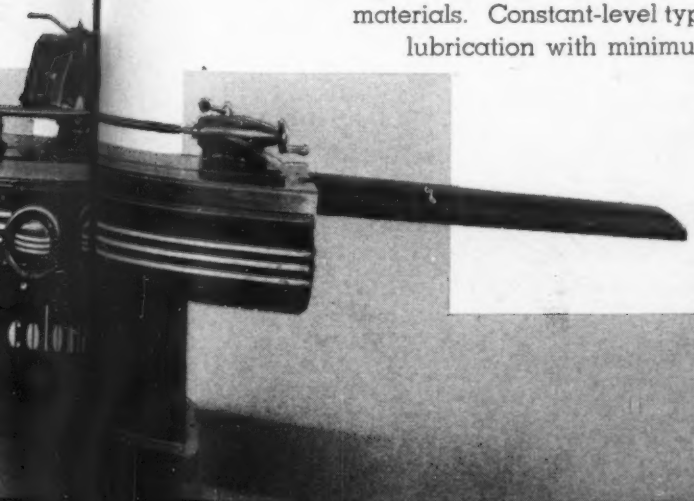


Left—With a capacity of 13 inches by 16 inches rectangular and 13 inches diameter round, the new Wells metal-cutting band saw extends the advantages of continuous metal cutting to larger jobs than previously could be handled on a low cost band saw. Feed and lift are hydraulically controlled

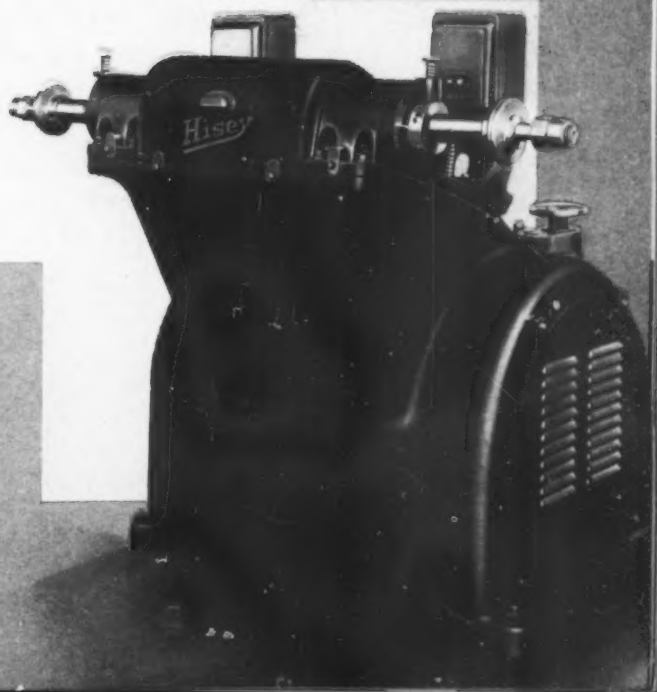
Above—Designed for general welding the [illegible] alternating-current welder has a stabilizing welding circuit which controls and balances voltage and current across the arc, decreasing spatter and insuring a homogeneous weld. A thermostatically controlled mercury arcless automatic cutout switch provides protection against excessive overloads



Left—Used as Air Corps ground equipment, the Denison spark plug tester proves in thirty seconds the performance of a plug under specified voltage and air pressure. Action of a hydraulic cylinder clamps the plug into an airtight chamber in which pressure may be up to 750 pounds per square inch



Right—Mounting the motors of the Hisey-Wolf heavy-duty polisher and buffer inside the base permits the use of standard motors in place of totally enclosed fan-cooled motors, with a corresponding saving in scarce materials. Constant-level type oilers provide lubrication with minimum attention



MACHINE DESIGN *Editorial*

Coordination Is Salient Keynote Till War Is Won

NECESSITY for drastic curtailment of rail travel has prompted the Office of Defense Transportation to urge the cancellation of meetings and conventions that will not directly aid in winning the war. Railroad facilities will be taxed to the limit in 1943, primarily through troop movements which have doubled during the past few months to a figure now approximating two million a month.

Many important association meetings already have been canceled and it is likely that scores of others, not necessarily vital to the war program, will be held over to more opportune times. It is to be hoped, however, that restrictions in travel, accommodation, etc., will not make necessary a cessation of engineering meetings and technical expositions—particularly so in the case of those meetings covering war equipment design and production in either closed or open sessions.

As pointed out recently by Donald Nelson, all the strength that can possibly be achieved must be used to create the maximum impact, this involving—as one factor—that improvements devised in one plant be speedily made available to all others and be put to use by them. This, of course, already is being done in connection with the interchange of patents in certain industries, and in the elimination of competition between companies in the automotive, aircraft and other fields. Such cooperation is even bringing about the actual loaning of manpower and the offering of engineering services by experienced companies to others embarking on new types of production.

Coordination of this nature in the effort to weld together a single wartime industry can unquestionably be aided by the continuance of engineering meetings and expositions. Neither design of armaments nor methods of production can be frozen longer than the time necessary to turn out sufficient materiel to meet current requirements. The jump ahead, each time that stage is reached, can be assisted markedly by free interchange of opinion, experience and ideas between responsible engineers.

L. E. Jerry

Determining Efficiency of Screw Threads

By R. D. Douglass* and J. M. Dunford†

IN THE DESIGN of screw threads, power screws and worm drives, the efficiency of the screw is determined by a formula which may take the following form:

$$\eta = \frac{\tan\lambda\,(1-\mu\sec\beta\tan\lambda)}{\mu\sec\beta+\tan\lambda}$$

where η = efficiency of screw
λ = lead angle of thread at pitch radius
= $\tan^{-1}$ [lead/($2\pi\times$mean radius)]
μ = coefficient of sliding friction
β = one-half the thread angle
= 30 degrees for American National standard threads
= 14½ degrees for Acme threads

This formula concerns only the friction of the thread and not of the nut, pivot or thrust collar. Inasmuch as the coefficient of friction differs from that at the thread, this effect must be separately figured.

An alignment chart for the solution of problems involving this formula is given on Page 84. To simplify the procedure, it is desirable to make the substitution

$$\mu_1 = \mu\sec\beta$$

where $\mu_1 = \mu$ in the case when $\beta = 0$, that is, for a square thread. The formula then becomes:

$$\eta = \frac{\tan\lambda\,(1-\mu_1\tan\lambda)}{\mu_1+\tan\lambda}$$

The chart will solve for square thread efficiencies directly, using the μ_1, λ and η scales. To take care of the American National standard and Acme threads, a multiplication scale is added. The appropriate point on the chart is lined up with the point on the μ scale, the extension of this line giving the value of μ_1. Since only two values of β are generally used in this country, only these have been indicated.

EXAMPLE 1—It is required to find the efficiency of a screw having 10 National standard threads to the inch on a three-quarter inch bolt. The mean or pitch radius of such a thread is .343-inch, and $\tan\lambda$ = lead/($2\pi\times$mean radius) = .1/($2\pi\times$.343) = .0464.

Assuming a coefficient of friction μ = .1, the point marked "National Standard" is lined up with .1 on the μ-scale, giving a value of μ_1 equal to .115. A line connecting this value of μ_1 with .0464 on the $\tan\lambda$ scale gives a value of efficiency equal to 29 per cent.

EXAMPLE 2—It is required to find the least thread angle which a square threaded jack can have and be self-locking. For this condition the efficiency must be less than 50 per cent. Assuming the coefficient of friction is .15, this value on the μ_1 scale is lined up with the 50 per cent point on the η scale, giving a value of lead angle equal to 8° 40′.

*Professor of Mathematics, Massachusetts Institute of Technology.
†Lieutenant, U.S.N

EFFICIENCY OF SCREW THREADS

$$\eta = \frac{\tan\lambda\,(1 - \mu\sec\beta\tan\lambda)}{\mu\sec\beta + \tan\lambda}$$

η = efficiency of screw threads

$\tan\lambda$ = $\dfrac{\text{lead of screw}}{2\pi \times \text{mean radius}}$

λ = lead angle

μ = coefficient of sliding friction

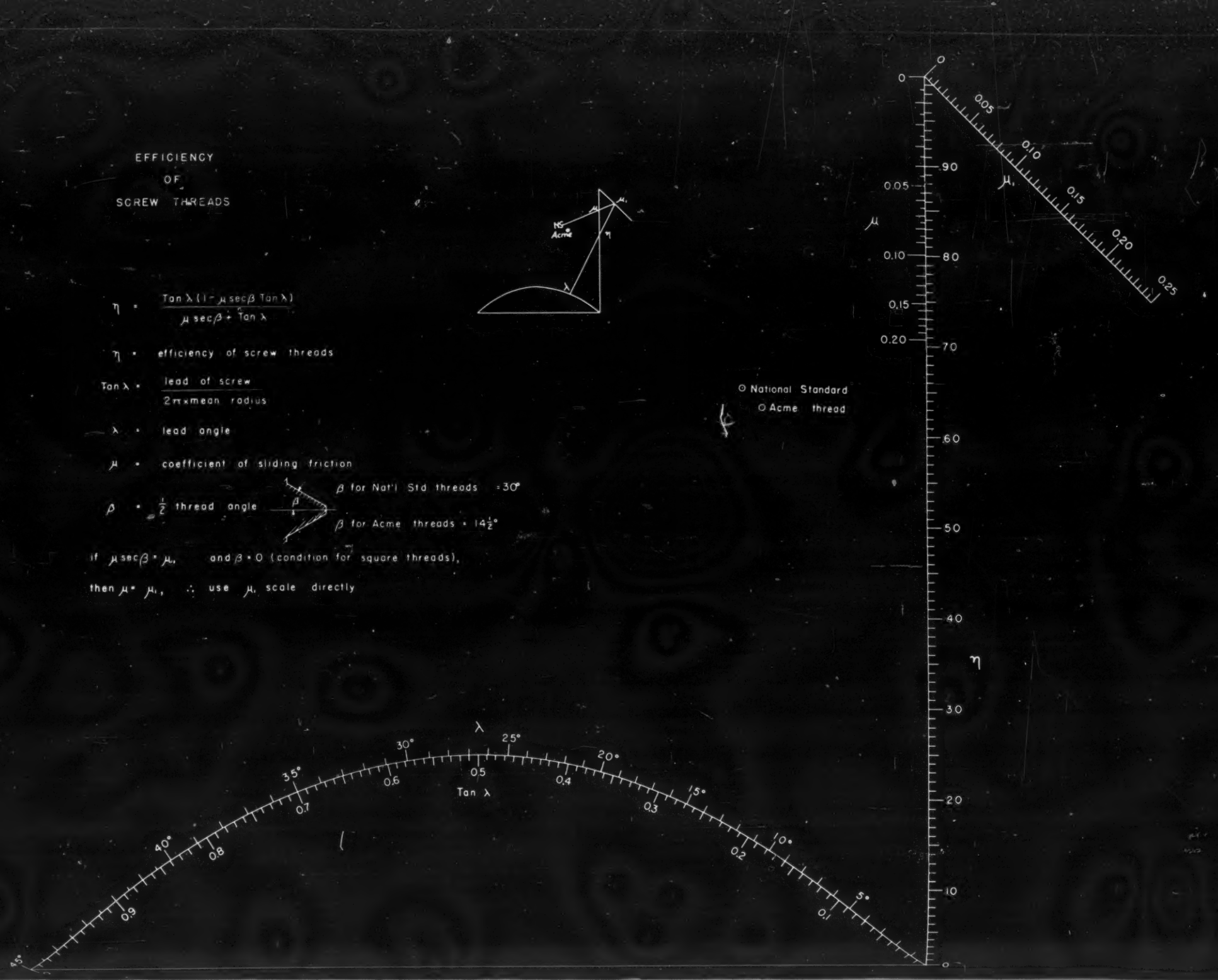
β = $\frac{1}{2}$ thread angle

β for Nat'l Std threads = 30°

β for Acme threads = 14½°

if $\mu\sec\beta = \mu_1$ and $\beta = 0$ (condition for square threads),

then $\mu = \mu_1$, ∴ use μ_1 scale directly



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◆ When you design your post-war product . . . start with the bearings.

Johnson SLEEVE TYPE bearings will help simplify the designing and construction problems on your new product. At the same time, they will give your customers the performance they have a right to expect . . . at the lowest cost possible.

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MACHINE DESIGN welcomes comments from readers on subjects of interest to designers. Payment will be made for letters and comments published

" . . . equation seems simpler"

To the Editor:

Your Data Sheet, "Velocity and Acceleration Analysis of Universal Joints" in the November issue presents Equations 1 and 2, giving the displacement and velocity of a driven shaft connected to a driving shaft by a universal joint, which, as is stated, are standard forms in most textbooks on mechanisms. Equation 6 is developed in the same form as found on Page 283, Vol. II of *Practical Solution of Torsional Vibration Problems*, 1941 edition, by W. Ker Wilson. Equation 7 follows directly from 6.

Since maximum values are usually desired in practical design, and since it is desirable to reduce all expressions to their simplest and most usuable form, the writer suggests the following, as developed in the paper "Harmonic Analysis of A Hook's Joint Motion", presented at the recent A.S.M.E. annual meeting:

$$\varphi=\theta-n\ sin\ 2\theta+\frac{1}{2}n^2\ sin\ 4\theta-\frac{1}{3}n^3\ sin\ 6\theta+---\ldots\ldots(a)$$

$$\omega_b=\omega_a-2n\omega_a(cos\ 2\theta-n\ cos^2 4\theta+n^2\ cos^2\ 6\theta-\ldots)\ \ldots.(b)$$

where

$$n=tan^2\frac{\beta}{2};\quad Cos\ \beta=\frac{1-n}{1+n};\quad \omega_{b\ max}=\omega_a+\frac{2n\omega_a}{1-n}$$

Therefore

$$\frac{\omega_{b\ max}}{\omega_a}=1+\frac{2n}{1-n}=\frac{1+n}{1-n}=sec\ \beta\ \ldots\ldots\ldots\ldots\ldots(c)$$

Expression *c* may be used in place of Equation 2 where maximum values are desired, and the general Equation *b* seems simpler in form than Equation 6 in which the coefficients are on infinite series.

From Equation *b*,

$$\frac{\alpha_b}{\omega_a{}^2}=4n\ sin\ 2\theta-8n^2\ sin\ 4\theta+12n^3\ sin\ 6\theta---\qquad(d)$$

It may be shown that, approximately,

$$\frac{\alpha_b}{\omega_a{}^2}\approx\frac{4n}{(1-n)^2}\ for\ 0<\beta<10^\circ\ \ldots\ldots\ldots\ldots\ldots(e)$$

and that the difference in numerical values between Equations *d* and *e* is small at $\beta=20$ degrees.

Equations *d* and *e* appear to be in simpler form for all purposes than Equation 7 where the coefficients are particularly cumbersome.

In *Fig.* 1 the author has added to the literature on the subject by plotting minimum values of ω_b/ω_a against angle β.

Five-place values of the relative displacements, velocities, accelerations and their significant harmonics have been tabulated in my aforementioned paper for $0<\beta<45$ degrees.

It is interesting to note that for $\beta=90$ degrees, Equation *c* shows that

$$\frac{\omega_{b\ max}}{\omega_a}=\infty\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(f)$$

and from Equation *e*

$$\frac{\alpha_b}{\omega_a{}^2}=\infty\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(g)$$

—FREDERICK A. HIERSCH
University of Michigan

Because a single term is less cumbersome than a series, as pointed out by Mr. Hiersch, Equations *b* and *d* will undoubtedly be found more convenient for the calculation of coefficients than the original Equations 6 and 7. Values calculated by either set of equations are in substantial agreement. Presentation of the acceleration coefficients in the form of curves (*Fig.* 3, Page 93, November) relieves the designer of the necessity of wading through calculations for these values.

Where accurate values of the maximum acceleration are needed, Equation *d* may be used in place of Equation 5, but it is necessary in either case first to find the appropriate value of 2θ, using the equation at the top of Page 94 in the Data Sheet. Inasmuch as Equation *d* is a series, it is probably less convenient than Equation 5.

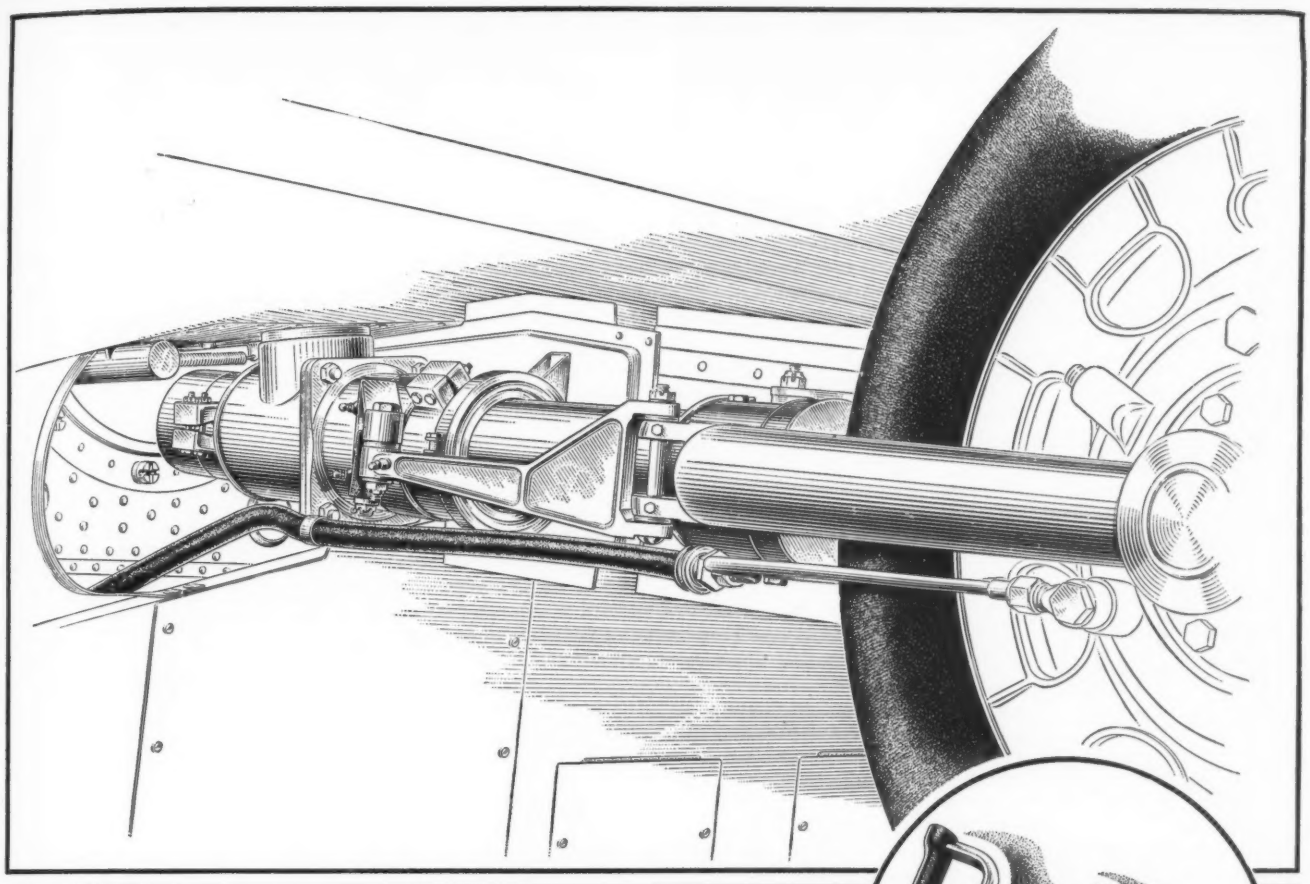
Mr. Hiersch's comments are much appreciated, and MACHINE DESIGN welcomes the opportunity to add to the information given in the data sheet.—ED.

" . . . offers helpful facts"

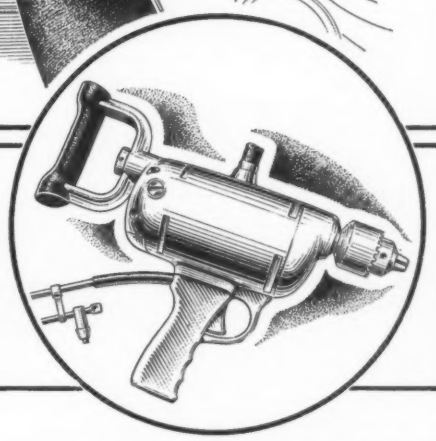
To the Editor:

I think MACHINE DESIGN did a real service in presenting the article "Felt Meets Wartime Demands" in the October issue, and for such wish to express our thanks. I think, too, you have offered industry in general some facts which may prove very helpful to it during this difficult period of war activity and the necessity for the use of substitute materials.

—H. S. COOK, *Vice President*
Standard Felt Co.



what the Landing Gear Learned from the Portable Drill



IT'S A LONG WAY from portable tools to fighter planes—but an idea that works in one often proves just as good in the other.

That's the way it was with the Torrington Needle Bearing. Portable tool builders quickly saw how its unusual features could be used to cut excess ounces out of their product designs—where *every* ounce counts in conserving the operator's energy, in increasing his efficiency.

These same weight-saving features also caught the attention of the airplane designers. When they needed a bearing that would give easy operation to retractable landing gears...stand up under the terrific impact when three tons of fighter plane hits the runway... and still meet the rigid weight requirements of fast, maneuverable aircraft, they found just what they wanted in the Needle Bearing's unique combination of low friction coefficient, high load capacity, and small size—plus its ready availability for war applications. That question of size is doubly important when it comes to weight economies. It means light weight in the bearing itself, of course. But much more important is the fact that housings and other parts can also be made smaller and lighter.

ISN'T THERE AN IDEA HERE FOR YOU TOO, as you get your post-war designs under way? This light-weight trend looks increasingly important, with freight-by-air looming up as the coming means of shipment. While you're studying ways to conserve weight in *your* products, see how well the Needle Bearing fits into your problem. You will find the preliminary information you want in Catalog No. 109—and Torrington engineers will help you in adapting the Needle Bearing to specific applications.

THE TORRINGTON COMPANY

Established 1866 • TORRINGTON, CONN., U. S. A.

Makers of Needle and Ball Bearings

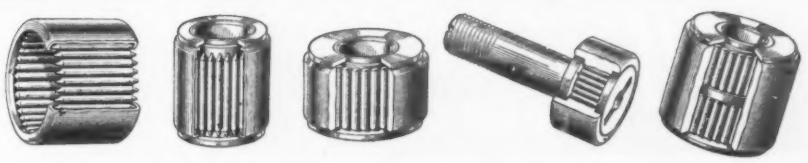
New York Boston Philadelphia Detroit
Cleveland Seattle Chicago San Francisco
Los Angeles Toronto London, England

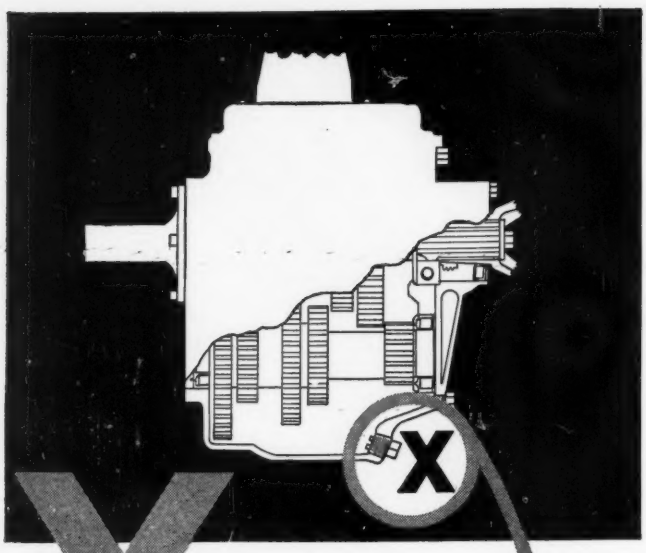
LET'S GO! U.S.A. KEEP 'EM FLYING

TORRINGTON NEEDLE BEARINGS

KEYED TO TODAY'S NEEDS

AND TOMORROW'S TRENDS

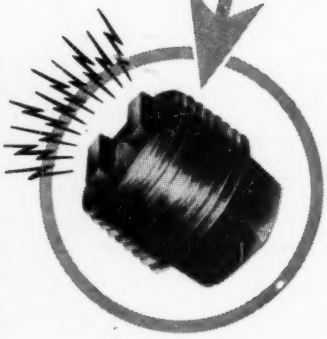


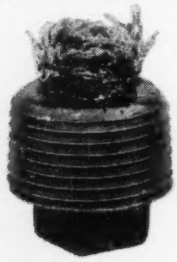


X MARKS THE SPOT

to stop excessive wear on Gears and Bearings

In the above cutaway drawing of a transmission, X marks the spot where an ordinary drain plug has been replaced with a Magnetic Plug. The powerful magnet in the Magnetic Plug catches and holds the iron and steel particles that are constantly forming in the lubricant as a result of ordinary wear. By removing this abrasive metal as fast as it appears, Magnetic Plugs eliminate one of the most common causes of excessive wear to bearings, gears and other vital parts.





Unretouched photo shows how a Magnetic Plug holds iron and steel particles

Low-cost Magnetic Plugs are now available for military equipment and war production machinery. Write for full information, prices and details on how you can obtain samples for testing.

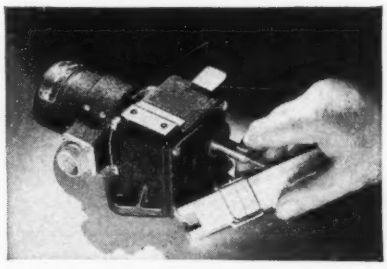
LISLE CORPORATION
Box 1003, Clarinda, Iowa

Magnetic DRAIN PLUGS

New PARTS AND MATERIALS

Aircraft Power Package

AIRCRAFT "Power Package" subassemblies—or driving mechanisms—have been introduced by General Electric Co., Schenectady. The design of the power package depends upon the application for which it is built, including bomb-door, landing gear, wing flap, control and protective device operation. It combines in one compact unit as many items as a motor, brake, clutch and limit switch, as well as indicators, gears and whatever is required to do a specific job. Designed for 24-hour



service, they can be obtained in ratings from 1/100 to 3 horsepower. Each element in the unit is reduced to save weight and space. Where a brake or a clutch can be used, the brake is chosen as it has only one moving part. A new planetary gear system permits the use of a magnetic brake for some applications. Of quick-acting friction type, the brake stops the motor quickly to prevent overtravel and consequent jamming of the driven assembly. When power is off, driven equipment is locked in place by brake, to eliminate creeping of such subassemblies as landing gear.

New Mountings for Power Relays

MODELS BO and BJ power relays for flight, firing and communication control have been redesigned by The Allied Control Co., 227 Fulton street, New York, to require minimum mounting space and to permit variations in their mounting bases to make them interchangeable. They are now available with mounting bases of bakelite, screw or nut, etc. Specifications of Model BO (bakelite mounting, Model BOB), shown in cut, are: Contact ratings, noninductive, 15 amperes for 12 and

VITAL CASTINGS

PRODUCED CENTRIFUGALLY by SHENANGO-PENN

Bearings • Bushings • Pump and Cylinder Liners
Rings • Propeller Shaft Sleeves • Washers

Centrifugal casting is a process that assures castings of greater strength . . . castings that deliver long trouble-free service. Sizes range from 2" diameter bearings to 26-inch by 26-foot long propeller shaft sleeves, and for contractors in war industries, our complete machining facilities are an added advantage.

Write for these bulletins today. They describe our products, alloys and facilities in complete detail.

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MONEL METAL
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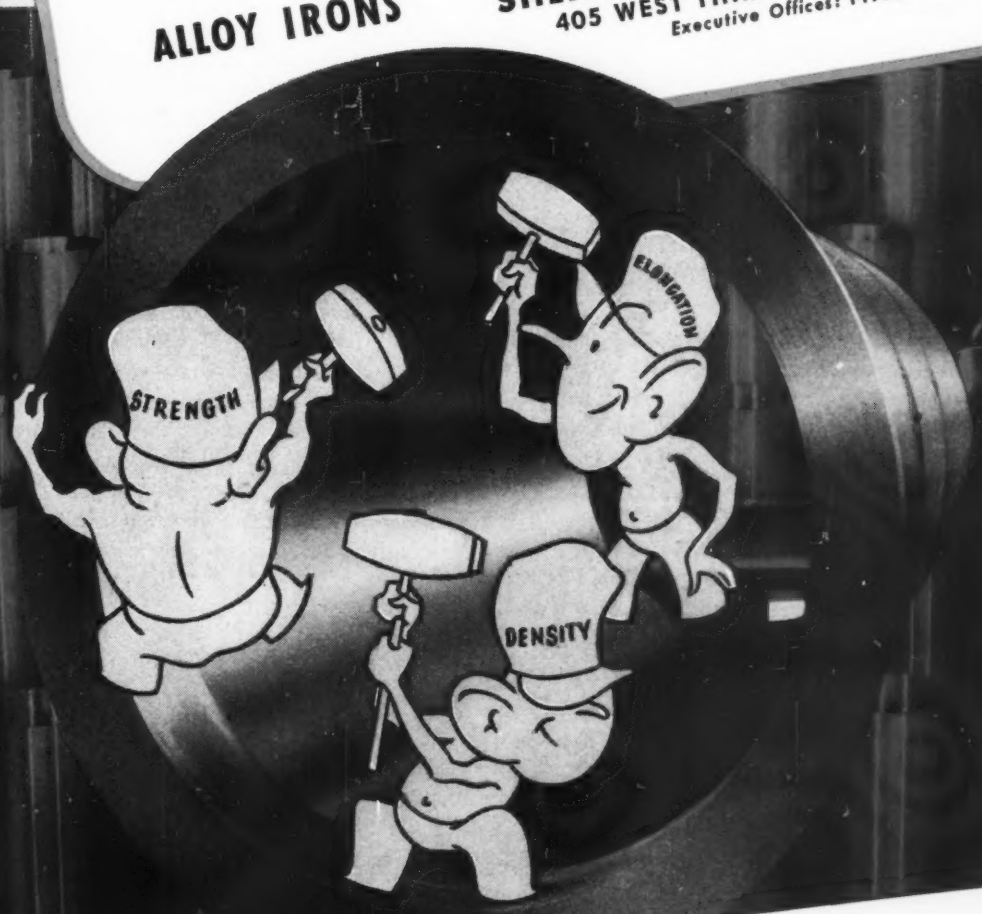
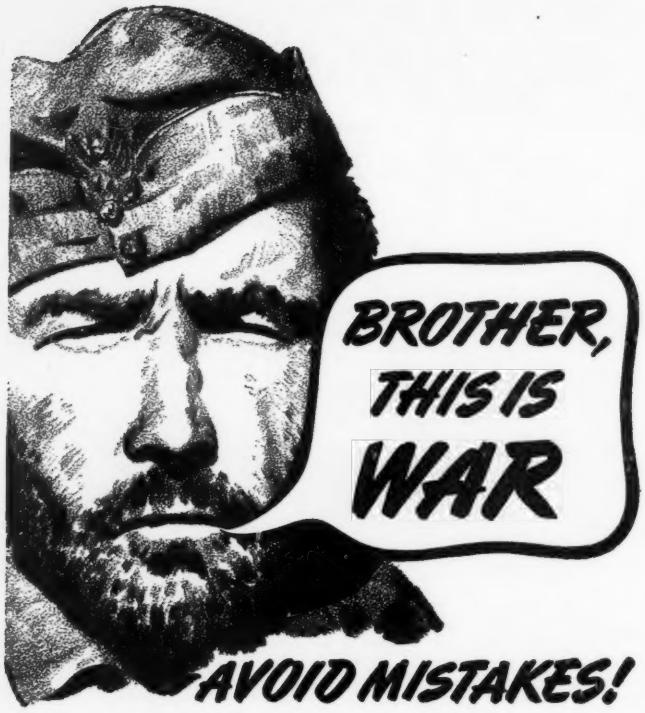


SHENANGO-PENN MOLD COMPANY



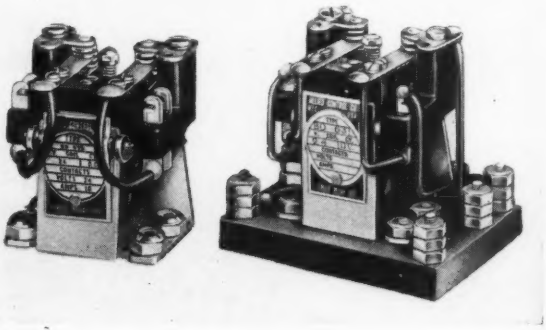
Guard precious war drawings with this special-process tracing cloth

Mistakes mean delays, and America's wartime job is to *speed* production! Give war jobs the best! That means specially-processed Arkwright Tracing Cloth.

Arkwright is made by a highly technical method on costly machines. The surface is clear, smooth – never "humpy." Ink lines won't spread or "feather" – nor crack or chip in drying. Years from now, drawings will be fresh and clear – truly permanent! Guard your war work this way. Arkwright Finishing Co., Providence, R. I.

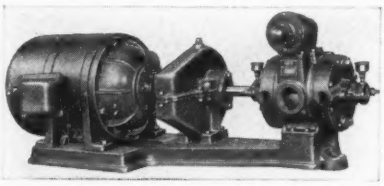
Arkwright
TRACING CLOTHS
AMERICA'S STANDARD FOR OVER 20 YEARS

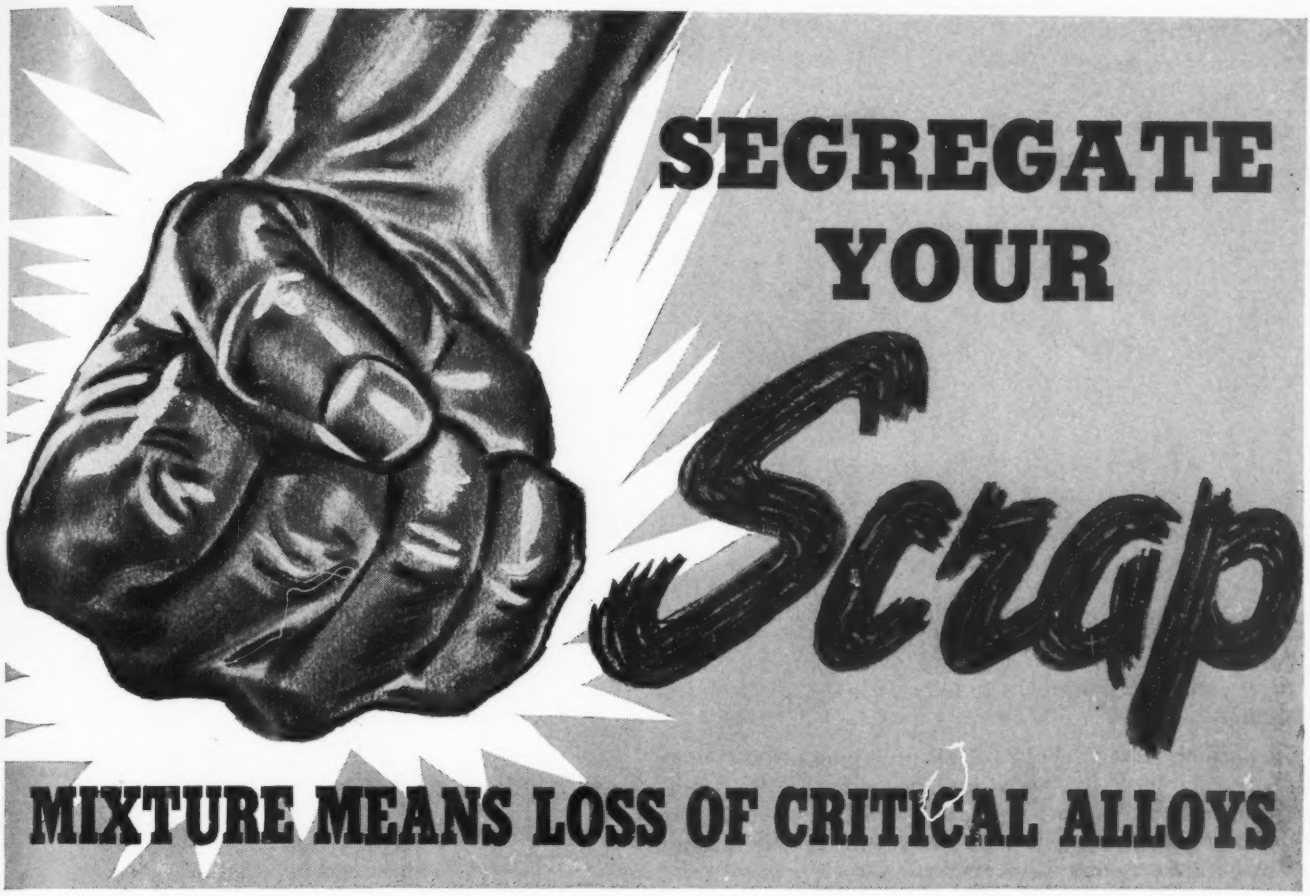
24 volts direct current and 110 volts alternating current; single or double pole, double throw; weights, 4 ounces with screw or nut mounting, or 7 ounces with bakelite mounting; withstands vibratory motion to 12G with 2½ watt operating power; operates at temperatures of +70 to —50 degrees Cent.; and dimensions for the screw or nut mounting, 1⅝ x 1 17/32 x 1⅞ inches or with bakelite mounting, 2⅝ x 1⅞ x 2 3/16 inches. Model BJ screw or nut mounted (Model BJB, with bakelite mounting) is available in the following specifications: Contact ratings, noninductive, 5 amperes for 12 and 24 volts direct current and 110 volts alternating current; single or double pole, double throw; weights, 2¼ ounces with screw stud mounting or 5 1/5 ounces with bakelite mounting; withstands vibratory motion to 12G with 2 watts operating power; and dimensions, with screw stud mounting, 2 5/16 x 11/16 x 1 9/16 inches or with bakelite mounting, 2 7/16 x 1 11/16 x 1 15/16 inches.



Pump with Steam-Jacketed Head

FOR handling such materials as palm oil, lard, tar, greases and similar liquids that must be processed or transferred while hot, a new and simplified steam-jacketed pump has been developed by Blackmer Pump Co., Grand Rapids, Mich. Made of cast semisteel with threaded intake and exhaust steam ports and drain plugs, the pumps are suitable for steam pressures up to 125 pounds. Sleeve bearings are sturdy, grease lubricated and located outside the pump casing away from pumpage. This heavy bearing construction eliminates shaft whip and distortion. For pressures in excess of 100 pounds per square inch, pumps are furnished with antifriction bearings. Stuffing boxes are deep with ample number of packing rings, and the stuffing box glands are of bolted type with back-off nuts. Standard units in capacities from 20 to 700 gallons per minute and pressures up to 300 pounds per square inch are available





SCRAP salvage is a vital factor in the war effort, and to be fully effective such a program must include methods for segregating and conserving critical alloying elements so urgently needed in the construction of war materials.

Ferrous and non-ferrous metal scrap should be collected in separate containers at the machine where they are generated. Each class of high-speed tool steel and each type of constructional alloy steel should likewise be kept separate so that the alloy content may be returned to service.

Remember,—alloy scrap which is segregated, classified and labeled according to type and composition is a vitally important commodity today—and urgently needed to augment primary supply of nickel, molybdenum, tungsten, etc.

The metallurgical experience of our technical staff is available to aid you in these and other phases of conservation.

KEEP SCRAP MOVING INTO WAR PRODUCTION!

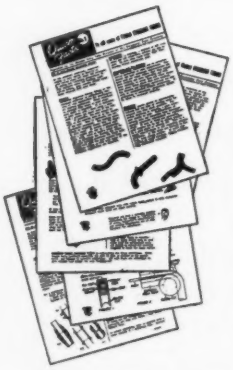
THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK, N. Y.

IF IT'S
HEAT RESISTANCE
YOU WANT

Exhaust collector rings, machine gun blast tubes and other products withstand corrosion and high heat, they have *longer service lives*—thanks to Carpenter Welded Stainless Tubing.

The *uniform wall thickness* of this tubing means that there are no thin spots to "burn out" first. And it is ductile, easy to fabricate—thus helping to speed the production of vital wartime equipment that must win battles against excessive heat. Then too, tubes are *natural design units*. Parts can often be finish-formed by merely swaging, tapering, expanding, etc.

If you have a wartime heat resistance problem that must be solved right now, take advantage of Carpenter's diversified experience in many plants where similar problems have been met and solved.



FOR HELP in applying Welded Stainless Tubing, ask for our series of "Quick Facts" bulletins. They contain practical working information to help you with new design and fabricating problems. A note on your company letterhead will start a set of "Quick Facts" bulletins on the way to your desk.

CARPENTER WELDED STAINLESS TUBING
meets Army and Navy specifications; resists corrosion, heat and wear; is 100% hydrostatically tested.

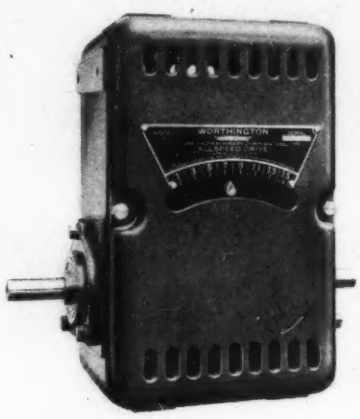
THE CARPENTER STEEL COMPANY
Welded Alloy Tube Div. • Kenilworth, N. J.

Carpenter
WELDED
STAINLESS TUBING

with the new steam-jacketed head, and are furnished with either single or double reduction gear drive and as single or multiple pump units.

Variable Speed V-Belt Drive

AN INTERESTING feature of the variable speed multiple V-belt drive, announced by Worthington Pump & Machinery Corp., Harrison, N. J., is its mechanical, positive belt-tensioning device which automatically compensates for increased arc of belt contact resulting from changing from low to high speeds. No springs are required in this device. Another feature is the fact that the drive need not be dismantled to change belts. Called the Allspeed drive, Model A has a horsepower range from one-third to three-quarters horsepower with a speed ratio



of 16 to 1, that is, any speed from ⅛ to twice the driving motor speed. Compact, ball-bearing equipped, and so designed that it can be operated in any plane, the drive can be coupled direct to any standard motor. It is flexible enough to be applied to any type of machine within its power range. According to the manufacturer, other sizes are now being developed for 1 to 3 horsepower, 3 to 5 horsepower, 5 to 7¼, and 7½ to 10 horsepower. While this drive was originally intended for machine tool application, it is already being used successfully on other types of equipment.

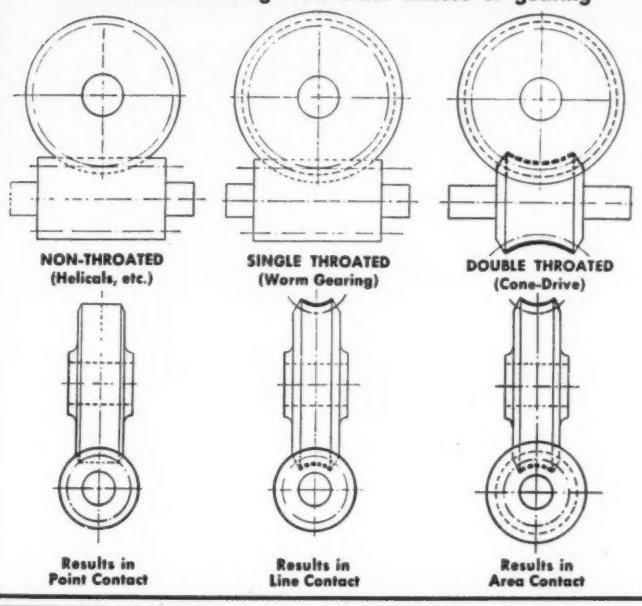
Three-Purpose Aircraft Contactor

KNOWN as the CR2791-Q100, a new three-purpose contactor made by General Electric company, is designed to start, reverse and provide dynamic braking for direct-current, split-field, series-wound aircraft motors having full-load currents up to ten amperes and locked rotor currents of 60 amperes at 12 or 24 volts, direct-current. Compact and light in weight, the contactor combines in one unit the functions of several single-purpose relays with their interconnections and mechanical interlocks. All moving parts are statically and dynamically mounted. The unit is corrosion-proof, and can be mounted in any position on either a metallic or nonmetallic base. Other features include operation at rated currents in ambient temperatures ranging from 95 to —40 degrees Cent. and at altitudes up to 40,000 feet. It will also

HOW TO GET MORE OUT OF YOUR CONE-DRIVE GEARING

. . . . . by correct assembly specifications

Below: Comparison of Double Enveloping Action of CONE-DRIVE Gearing with other classes of gearing



Good alignment is essential for assurance of maximum life for any type of gearing. The better the alignment the longer the life and the smoother and quieter the gears will be in operation. That applies to Cone-Drive as well as worm and other forms of gearing.

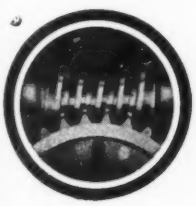
CONE-DRIVE GEARING is no more "sensitive" to misalignment than other forms of gearing. In any form of gearing certain dimensions must be watched to assure satisfactory assembly.

Thus, in non-throated gearing (i.e., non-enveloping helicals, etc.) the assembly tolerances of chief importance are those affecting center distance.

In single throated worm gearing (single-enveloping) gear side position should be held to the same tolerances as center distance.

In Cone-Drive gearing (double enveloping) the end position of the pinion (or 'worm') should also be held to the same tolerances as center distance and side position.

Cone-Drives on the other hand have an advantage in that BOTH pinion and gear are regenerative: therefore tend to correct themselves in service if assembled in slightly misaligned position.

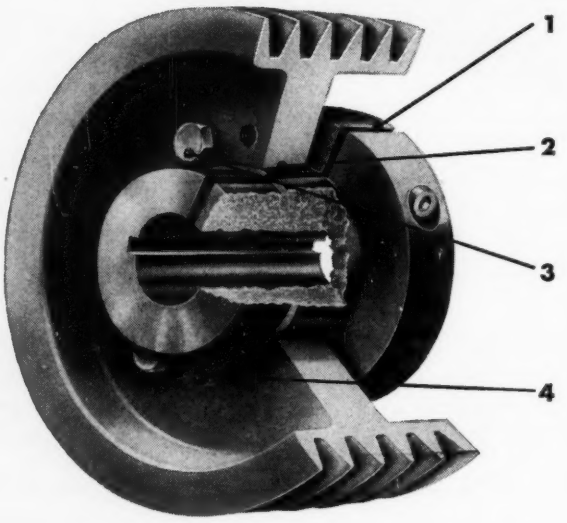


CONE-DRIVE DIVISION MICHIGAN TOOL COMPANY
7171 E. McNichols • Detroit, U.S.A.

WORTHINGTON QD QUICK DETACHABLE SHEAVES

Easy to get on
Easy to get off

...YET ALWAYS TIGHT ON THE SHAFT



1. **SPLIT HUB** for easy mounting or removal from the shaft.
2. **TAPERED FIT** between split hub and rim for easy mounting or removal of rim from hub.
3. **PULL-UP BOLTS** which pull the rim onto tapered split hub for tapered friction drive assembly and positive press fit on the shaft.
4. **TAPPED HOLES IN RIM** for using pull-up bolts as jack screws to free the tapered friction fit when detaching the rim.

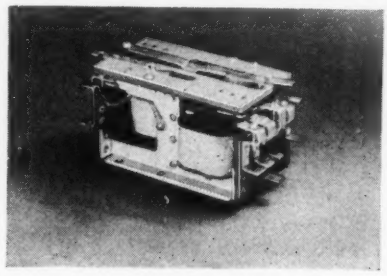
MEMBER V-BELT ASSOCIATION

Ask our nearest District Office for a demonstration of the Time-Saving, Labor-Saving and Material-Saving advantages of the QD Sheave.

MV3-1

WORTHINGTON
COMPLETE DRIVES — MULTI-V-DRIVES — SHEAVES OR BELTS ONLY
WORTHINGTON PUMP & MACHINERY CORPORATION - GENERAL OFFICES: HARRISON, N. J.

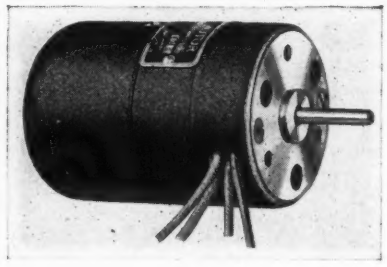
withstand 95 per cent humidity at 75 degrees Cent. on 48-hour tests, with immediate operation thereafter. The balanced-armature construction assures that when the relay is in either energized or de-energized state, the contacts will remain in open or closed position even when



subjected to mechanical frequencies of 5 to 55 cycles per second at 1/32-inch maximum amplitude (1/16-inch total travel) applied in any direction, or when subjected to a linear acceleration of ten times gravity in any direction.

Motor for Aerial Cameras

FOR aircraft aerial cameras, Signal Electric Mfg. Co., Menominee, Mich., has designed a small fractional-horsepower motor. Wrinkle finished, the motor is 1/120-horsepower, 12 volts, with a speed of 6000 revolutions



per minute. Ball bearing-fitted, the motor weighs 14 ounces. Diameter of housing is 2-3/16 inches, overall length, not including shaft, 3-7/32 inches, with shaft extension 1 inch and shaft diameter .1875-inch.

Coated-Fabric Diaphragms

PROPERTIES of "Fairprene" coated fabrics, announced by the Fabrikoid division of E. I. du Pont de Nemours & Co., Fairfield, Conn., disclose that this material approaches natural rubber-coated fabrics. The material is resistant to deteriorating action of crude petroleum oils or any of its refined products. Used for airplane cloth, the material is available in sheet form in continuous length rolls up to 25 yards and 36 inches in width. It is stocked in two hardnesses. Diaphragms of this material are flexible over a wide temperature range, being heat resistant up to 300 degrees Fahr. Temperatures as low as —40 degrees Fahr. do not stiffen the diaphragms to an appreciable extent. The diaphragm material being responsive to the slightest pressure changes, uniform operation is possible, and long service life is obtained due to

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ALBANITE produces a Better Tracing Paper

No wonder this remarkable new tracing paper has found its way into the best drafting rooms in America. It gives you every possible drawing advantage, *and a permanence that protects your tracings against the ravages of time!*

For ALBANENE is made of 100% long fiber pure white rags—treated with *ALBANITE*—a new crystal clear synthetic solid developed in the K&E laboratories. It is free from oil and wax, physically and chemically inert. ALBANENE will not oxidize, become brittle or lose transparency with age.

Even more to the point, ALBANENE has an improved drawing surface that takes ink or pencil fluently and erases with ease... A high degree of transparency that makes tracing simple, produces strong, sharp blueprints... Extra strength to stand up under constant corrections, filing and rough handling. ALBANENE has *all* the working qualities you have always wanted *and it will retain all these characteristics indefinitely.*

Let ALBANENE prove its merits on your own drawing board, under actual drafting conditions. Ask your K&E dealer, or write us for an illustrated brochure and a generous working sample...

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KEUFFEL & ESSER CO.

NEW YORK—HOBOKEN, N. J.

SAN FRANCISCO · CHICAGO · ST. LOUIS · LOS ANGELES · DETROIT · MONTREAL

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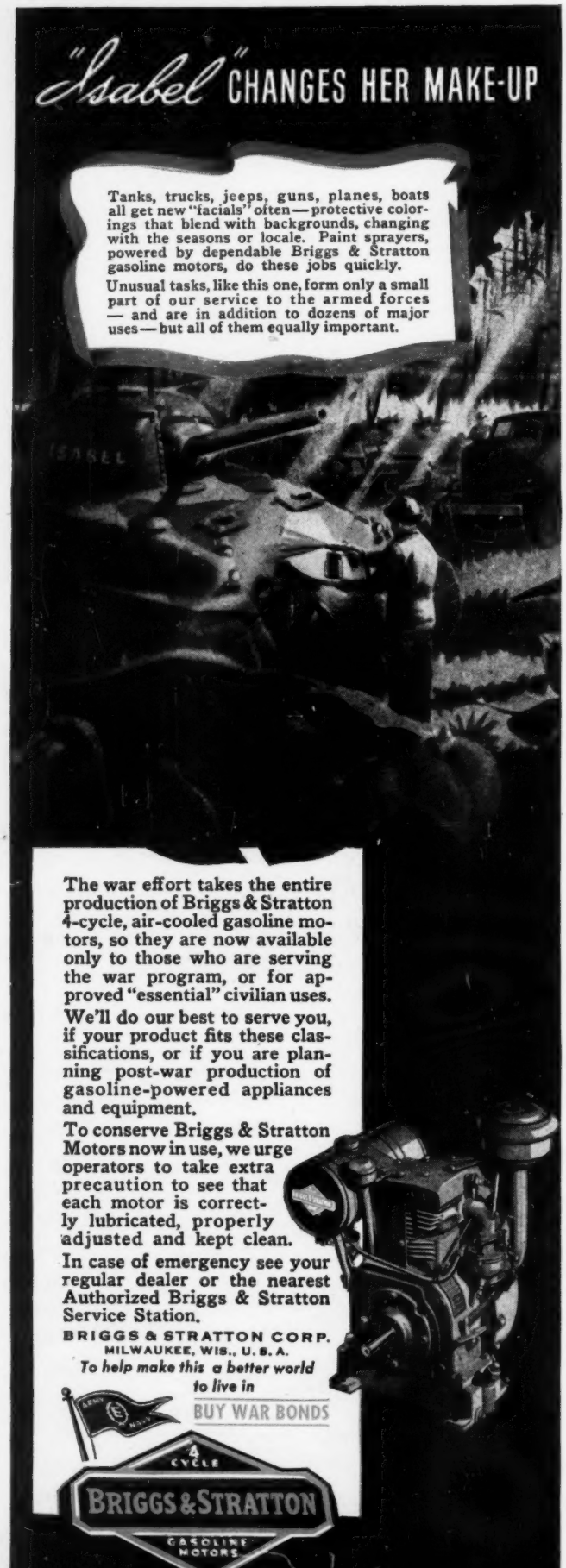
REG. U. S. PAT. OFF.

THE STABILIZED TRACING PAPER

MINERAL OIL. Most tracing papers are treated with some kind of oil. Mineral oil is physically unstable, tends to "drift", never dries completely. Papers treated with mineral oil pick up dust, lose transparency with age.

VEGETABLE OIL, chemically unstable, oxidizes easily. Papers treated with vegetable oil become rancid and brittle, turn yellow and opaque with age.

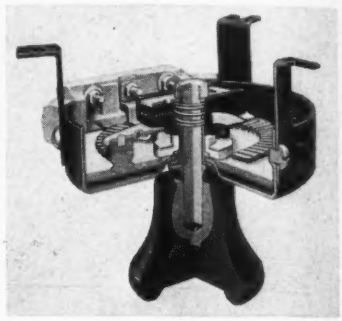
ALBANITE is a crystal-clear synthetic solid, free from oil and wax, physically and chemically inert. Because of this new stabilized transparentizing agent Albanene is unaffected by harsh climates —will not oxidize with age, become brittle or lose transparency.


"Isabel" CHANGES HER MAKE-UP
Tanks, trucks, jeeps, guns, planes, boats all get new "facials" often — protective colorings that blend with backgrounds, changing with the seasons or locale. Paint sprayers, powered by dependable Briggs & Stratton gasoline motors, do these jobs quickly.
Unusual tasks, like this one, form only a small part of our service to the armed forces — and are in addition to dozens of major uses — but all of them equally important.
The war effort takes the entire production of Briggs & Stratton 4-cycle, air-cooled gasoline motors, so they are now available only to those who are serving the war program, or for approved "essential" civilian uses.
We'll do our best to serve you, if your product fits these classifications, or if you are planning post-war production of gasoline-powered appliances and equipment.
To conserve Briggs & Stratton Motors now in use, we urge operators to take extra precaution to see that each motor is correctly lubricated, properly adjusted and kept clean.
In case of emergency see your regular dealer or the nearest Authorized Briggs & Stratton Service Station.
BRIGGS & STRATTON CORP.
MILWAUKEE, WIS., U. S. A.
To help make this a better world to live in
BUY WAR BONDS
4 CYCLE
BRIGGS & STRATTON
GASOLINE MOTORS

the ability to withstand constant flexing action. Fairprene diaphragms are used in temperature and pressure control equipment, vacuum-operated devices and in parts such as spark controls, speed governors, starterators, choke controls, fuel pumps, carburetors, automatic gear shifts, vacuum booster pumps and vacuum power brakes. The sheets are also used for gaskets, washers and packings.

Pressed Steel Rheostats

FOUR-INCH, pressed steel rheostats, offered by Ward Leonard Electric Co., Mount Vernon, N. Y., meet the need for a small, sturdy, power rheostat having a large number of steps and ample current-carrying capacity. These new rheostats have as many as 43 steps of control and are rated for 100 watts. Spacings through air and creepage distances between parts of opposite polarity and between current carrying and grounded parts meet the requirements of A.I.E.E., N.E.M.A. and Underwriters Laboratories for 300-volt service. Other features of the rheostats are the balanced contact arm, dead-shaft construction, copper graphite contact shoes and front or back-of-board mounting in single and multiple assemblies.



Varnished Silk Alternatives

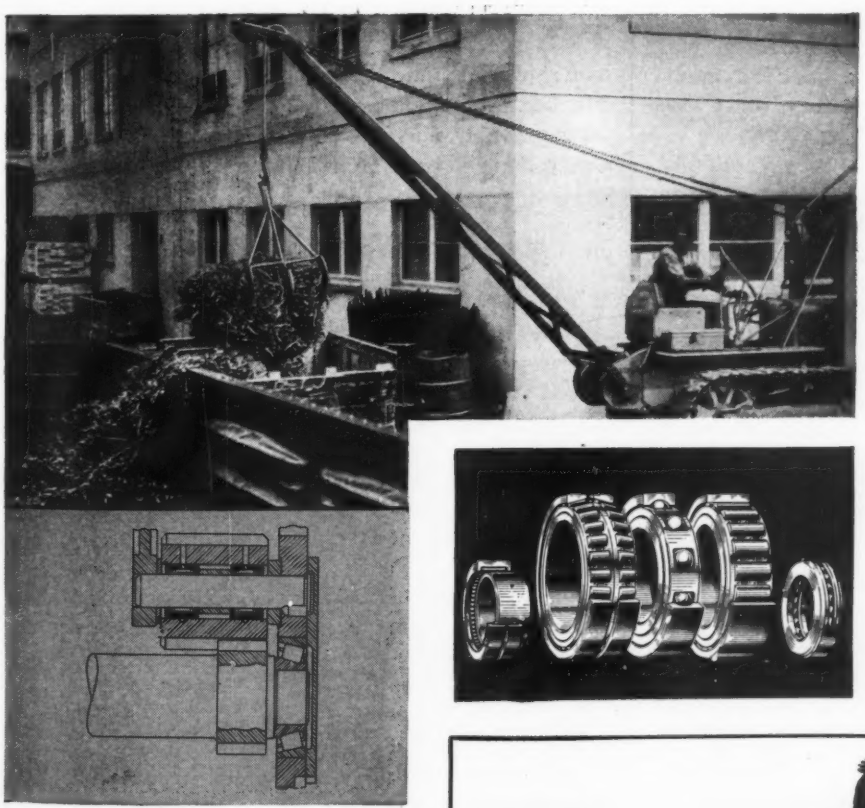
FOR electrical insulation formerly provided by varnished silk, Irvington Varnish & Insulator Co., Irvington, N. J., has developed three new insulating alternates in its varnished rayon, varnished cotton cloth and varnished nylon. These materials possess good dielectric strength with tensile and tear strengths equal to or better than the varnished silk, and can be punched into special shapes. They are available in thicknesses from .003 to .008-inch in straight-cut rolls or bias-cut strips in 51-inch lengths. Comparing favorably with varnished silk in strength and flexibility, the high tenacity varnished rayon is the most suitable alternative. It has a dielectric strength of 1200 volts per mil. Varnished cotton cloth has greater tensile strength, and its pliability permits application in odd shapes. Dielectric strength is 1200 volts per mil also. Varnished nylon with its flexibility, high tensile strength, and 1200 volts per mil dielectric strength, is only available by government allocation.

Two Leathers in V-Belt Plies

BECAUSE of the shortage of rubber, Victor R. Clark Belting Co., 605 West Washington boulevard, Chicago, has placed on the market its continuous length, leather V-belt with a ball bearing fastener. Carrying the same horsepower ratings and the same minimum pulley

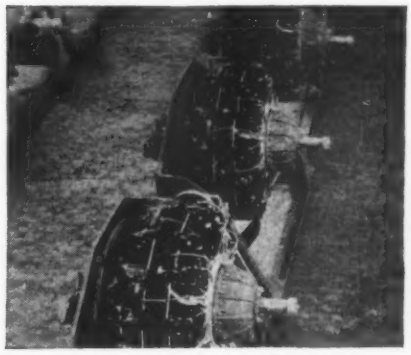
IN THE NEWS
WITH BANTAM BEARINGS

70 TONS OF FLYING BOAT, the Mars provides a new cargo carrier of tremendous speed, and offers a forecast of the aerial transportation of the future. Built for the Navy by The Glenn L. Martin Company, the Mars, with its 200-foot wing spread and its four 2000-HP motors, requires a giant beaching gear to maneuver it on land. And in the gear the entire load is carried on large-size Bantam Ball Thrust Bearings made of stainless steel to resist attack by salt air and water—another instance of Bantam's skill in supplying bearings for radically new requirements.



FROM TOWING WINCH TO CRANE by the addition of a boom is the transformation undergone by this versatile Willamette Hyster winch, now handling scrap in a metal refining plant. Winches of this type use Bantam Quill Bearings on reverse idler pinion (as shown in cross-section drawing) and in idler gear.

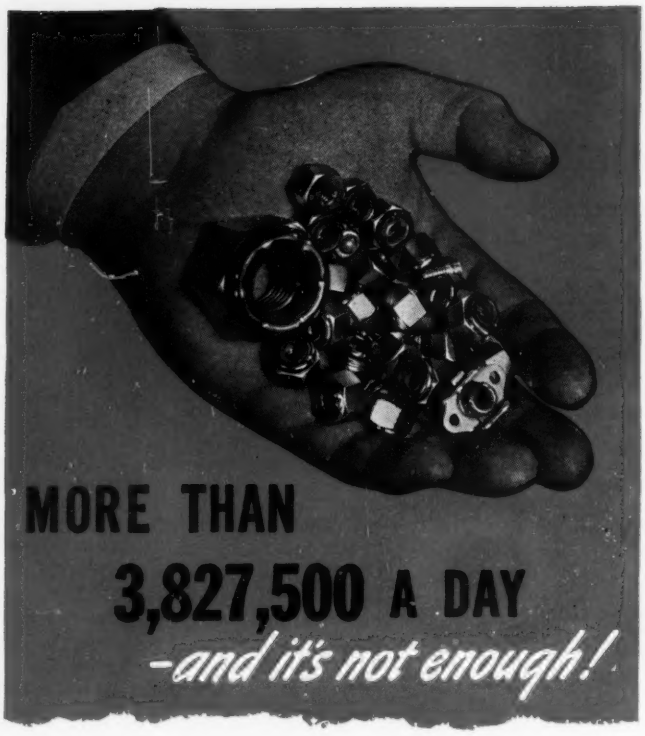
THE GENERAL GRANTS CAN TAKE IT, as these 30-ton tanks conclusively demonstrated in the Egyptian campaign. And in the tank transmissions, Quill Bearings are again proving their ability to perform efficiently and reliably under the most severe service conditions. For further information on this compact, high-capacity anti-friction bearing, write for Bulletin B-104.



BANTAM NEEDLE ROLLERS are assembled into anti-friction units of exceptionally high load capacity, low cost, and small size, for use in many of America's foremost aircraft engines. Where anti-friction is a *must*, and size, weight, and installation are factors in design, Bantam Needle Rollers fill many important jobs.

←IF YOU NEED ANTI-FRICTION BEARINGS for war applications or tomorrow's designs, you will probably find what you want among Bantam's comprehensive line, which includes straight roller, tapered roller, needle, and ball. Or if you need *special* bearings, Bantam engineers will design them. For help on your bearing problems, TURN TO BANTAM.

BANTAM BEARINGS
STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL
BANTAM BEARINGS CORPORATION • SOUTH BEND • INDIANA



EVERY single day almost four million Elastic Stop Nuts go into war production.

Even at that, and with all our expanded plant, it doesn't fill the demand.

It happens that the most urgent need right now is on aircraft. Every American plane that takes the air has some important part of its structure fastened with these strong, tight-holding nuts. Some types take as many as 35,000 in a single ship.

The reason is: *these nuts stay put under the toughest circumstances.*

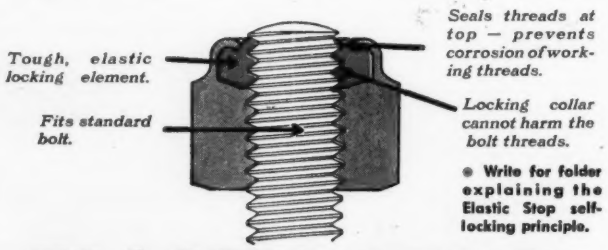
You handle them exactly like regular nuts. They go on fast, lock immediately and automatically.

There's no need of pins, washers or auxiliary locking devices.

Once on, they stay there — never shake loose. But you can take them off and put them back on many times and they won't lose their locking ability.

This is why there are more Elastic Stop Nuts on America's planes than all other lock nuts combined. And why they are also used in important structural applications on guns, naval vessels and other war equipment.

We have made billions of Elastic Stop Nuts and, as far as we know, not one has ever loosened.


Tough, elastic locking element.
Fits standard bolt.
Seals threads at top — prevents corrosion of working threads.
Locking collar cannot harm the bolt threads.

• Write for folder explaining the Elastic Stop self-locking principle.

ELASTIC STOP

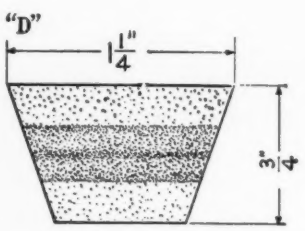
SELF-LOCKING NUTS AND AIRCRAFT FITTINGS

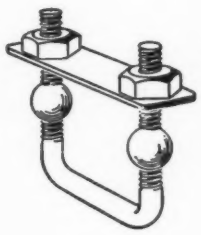
ELASTIC STOP NUT CORPORATION

2330 Vauxhall Road, Union, N. J.

WITH THE RED COLLAR—SYMBOL OF SECURITY

limitations as rubber V-belts, the new waterproof, oil-resistant belting can be used for similar applications. It is said that the construction of the leather belts, consisting of different grades and kinds of leather in the middle and outside plies, forces the line of pull from the pitch line (on the straightaway) to the outside ply or top of the belt as it arcs around the pulley. Balls of the fas-





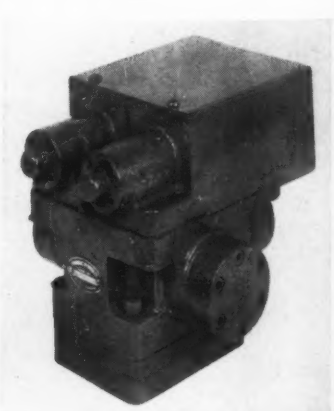
teners ride the middle ply and the arms are free to move as the belt bends, thus preventing a stiff spot at the joint. The pulley grip increases while the belt is in use, being at its lowest efficiency when installed. The middle ply doing the pulling is tough, high tensile strength, stretch-resisting leather, while the outside plies are of wear-resisting but elastic leather which spreads and grips pulley sides.

New Finish for Aircraft

RECENTLY introduced by S. C. Johnson & Son Inc., Racine, Wis., a wax finish previously used on automotive work is now being utilized on aircraft. The finish is a wax application for wing coverings and exterior surfaces generally, and may be sprayed, brushed or wiped on. One gallon will cover from 2500 to 3000 square feet.

Four-Way Valve, Spring-Centered

FEATURING either closed or open-center operation by a slight mechanical adjustment, an improved four-way valve has been developed by Hydraulic Hi-Speed Co., 5438 Tireman avenue, Detroit. Used wherever spring-centered four-way valve operation is desired, it permits a change to a different type of operation without replacing valve. Removal or installation of a ⅛-inch socket pipe plug is all that is necessary. Available in three models of 10, 18 or 28 gallons per minute capacity, with a maximum recommended working pressure of 2000 pounds per square inch, the valve is furnished complete with subplate and solenoids in a choice of voltage and current characteristics. Need for a separate pilot pressure system



Even with a Green Operator—

You could start a green man every morning without a moment's worry over the safety of your bearings—

If they were protected by a Farval Centralized System of Lubrication.

With no expert attention Farval Centralized Systems will protect you in advance against disastrous shut-downs due to faulty lubrication. A few strokes of the Central Pumping Unit gives every bearing the amount of lubricant it requires and—not a bearing is missed.

Farval increases machine production hours. In less than one minute and while the equipment is in full operation, complete lubrication is obtained in perfect safety from the floor.

Farval enables you to return used equipment to profitable service. With bearings properly lubricated, even the older machines are able to carry the load.

Why not protect *your* equipment against the hazards of the Green Operator? Install Farval!

The Farval Corporation, 3265 East 80th St., Cleveland, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Manufacturers of Automotive and Industrial Worm Gearing
In Canada: PEACOCK BROTHERS LIMITED

Hunter *Electro*-Copyist Machine-Made Tracings

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For speed and efficiency in wartime engineering, design and production departments, Electro-Copyist is an almost indispensable aid. Every sort of copying complication is reduced to the absolute minimum with this revolutionary machine. Copyist can produce up to 25 perfect, photoexact tracings an hour . . . a mere fraction of hand-drawn time . . . yet it's so simple anyone can run it, and it needs no dark room, has no lens.

For priority extensions, specifications, complicated plans—anything drawn, printed, typed or photographed—you can't beat Electro-Copyist for sharp, clear contact prints. Don't waste valuable drafting room hours—don't let paper-work bog you down—write us today for our big new folder illustrating many drafting room shortcuts and vital-time-savers, possible through this amazing new duplication method. Illustrates many different models from small portables to 42" machines. Don't delay—write now!

Hunter Electro-Copyist, Inc.
431 South Warren St.
SYRACUSE, NEW YORK

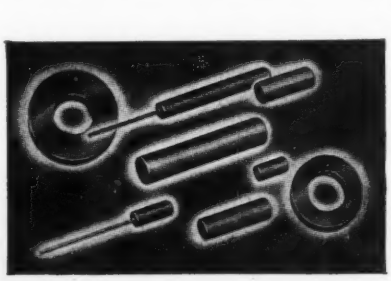
is eliminated because valve contains integral dumping valve. Main valve spool, normally spring centered, is operated hydraulically by pilot valves, which are normally spring offset. In turn these are activated by solenoids to produce a full range of four-way valve operation. When adjusted for closed center, de-energizing the solenoids blocks all ports; while, when adjusted for open center, de-energizing the solenoids blocks the cylinder ports but leaves pressure open to tank. By-passing of oil is permitted by use of open center, thus conserving horse-power and reducing heat transfer during a long idle period.

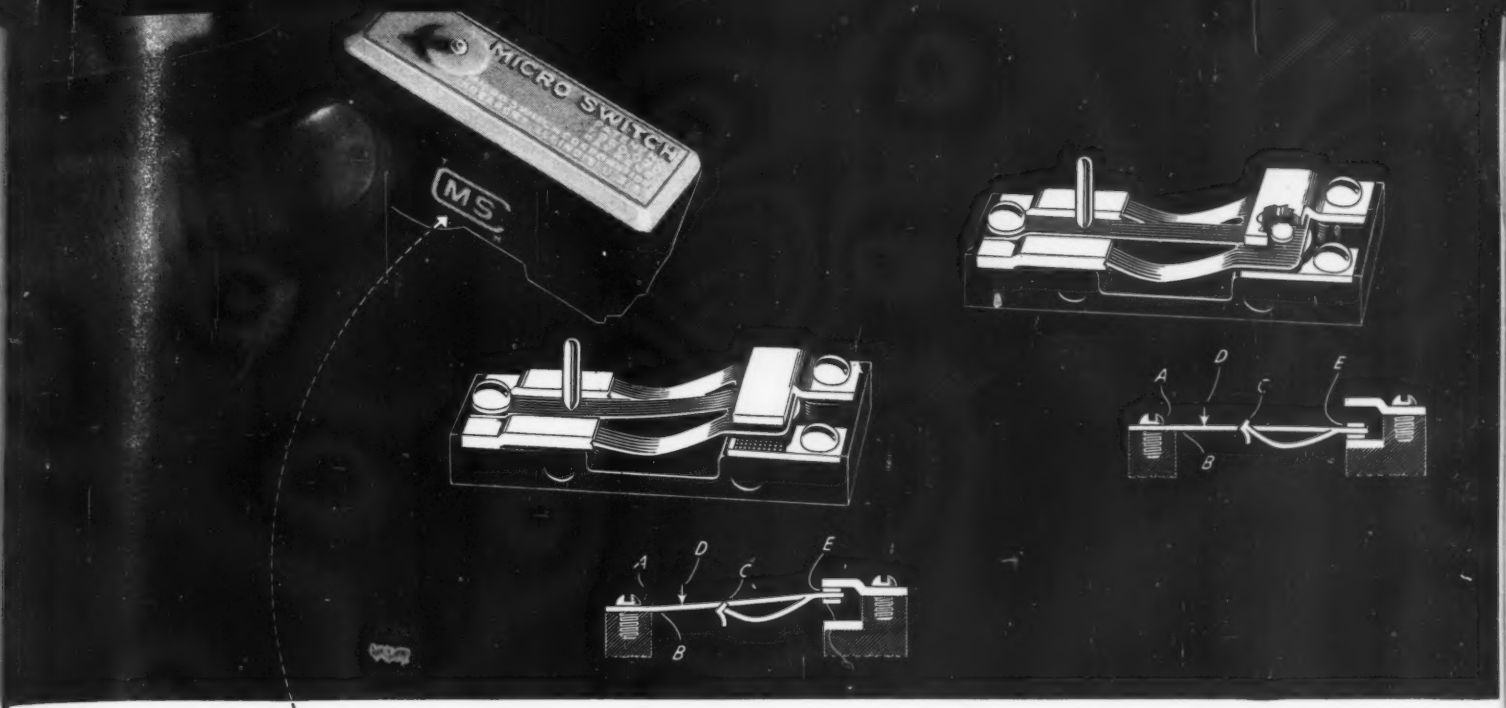
Nuts for Plywood Use

DESIGNED for plywood, self-locking speed nuts introduced by Tinnerman Products Inc., 2085 Fulton road, Cleveland, can instantly be driven into anchored position. The cam-like structure of the two pair of integrally formed attaching legs forces the legs outward as the nuts are driven into plywood, permanently holding nuts with firm spring-tension grip in the wood. When driven into thick plywood sections, the attaching legs "peen" over when driven against a backing plate. Another advantage of the nuts for plywood use is the light weight of only 3½ pounds per thousand. The larger bearing surface of the nut spreads the load over a greater area. For assembly of plywood parts of planes, gliders and other aircraft equipment the nuts are made for use on both Air Corps 530-8 and 530-10 screws which are the standard type "Z" sheet metal screws.

Molded Iron Cores Available

IRON cores for use up to 150-175 megacycles have recently been developed by the Stackpole Carbon Co., St. Marys, Pa. These molded cores, showing outstandingly favorable characteristics at these frequencies, combine a permeability of approximately 5 with high Q.;





Without This Mark MS It Isn't a Micro Switch

There is only one micro switch—the MICRO SWITCH—manufactured by this company. When you buy a precision snap-action switch, it is not a MICRO SWITCH unless it has the now familiar trademark shown on the side of the switch as illustrated above.

The MICRO SWITCH is thumb-size, feather-light, and operates precisely at the same point for millions of operations with lightning-fast contact action. It is accurately built to exact standards from precisely made parts. Its performance characteristics can be changed to meet functional requirements. It can be furnished with many types of actuating mechanisms and protective housings.

The MICRO SWITCH is the only precision snap-action switch available to you which employs the principles of design illustrated above and described below.

The MICRO SWITCH principle is different. It involves no reverse bends—no buckling "oilcan" action. The long member of the one piece, three bladed, beryllium copper leaf spring "B" is supported in cantilever at "A". The two short members are curved in compression to rest in the notches at "C." These two strut-like springs exert an upward force to hold the electrical contacts "E" together with a force of 40 to 100 grams, depending on the type of switch. The operating force applied at "D" deflects the longer tension member downward in a gentle curve until the upward force of the bowed members is overcome and the contact end of the spring moves downward with the sharp, snap-action which makes clean cut electrical switching. The distance the contacts are separated is controlled to suit the particular problem at hand, and may be as much as .070 inches for high altitude aircraft use. Removal of the force at "D" allows equally fast snap-return to the original position... The electrical contact moves in the same direction as the operating force. This direct action not only provides accurate performance, time after time, for millions of operations, but should there be a welding or sticking of contacts due to overload, the direct-acting force acts as insurance to break the weld and to put the switch back into service.

On present or future designs it will pay you to consider the many advantages in space saving, accuracy, precision performance, and the dependability of a snap-action switch. But when you do, be sure that you select a MICRO SWITCH for the reasons enumerated above. Shown below are typical applications, and the two catalogs illustrated in the lower left hand corner of these pages will be highly advantageous to you in incorporating the MICRO SWITCH into your design.

How and For What Micro Switches Are Used

This illustration shows the Micro Switch with a spring leaf actuator serving as a break indicator as used in textile mills or paper mills.

This shows an explosion proof Micro Switch used with a spray gun which automatically cuts out the entire operation of the spraying booth when the gun is shut off.

This illustration shows a Micro Switch enclosed in a die cast housing with a synthetic rubber seal, and is being used as a lathe carriage stop.

This illustration shows a Micro Switch with a pushbutton actuator being used as a safety switch in a high tension cabinet door. It is a normally open switch in which the circuit is opened as the door is opened.

This illustration shows two steel enclosed Micro Switches which serve as overrun limit switches on a machine tool.

This illustration shows the use of two Micro Switches with spring type plungers to insure safe positioning of material in a punch press or a similar tool.

This illustration shows use of a Micro Switch with a spring plunger which is actuated by the pressure of a liquid in a line as the actuating medium.

SEND FOR THESE CATALOGS

Your up-to-the-minute engineers will thank you for keeping them informed about the Micro Switch. Send for as many of the Handbook-Catalogs illustrated here as you think necessary. No. 60 covers Micro Switches in general; and No. 70 deals with specific Micro Switches for use in aircraft.

Switch is a trade name indicating manufacture by Micro Switch Corporation

MICRO MS SWITCH

Manufactured in FREEPORT, Illinois, by Micro Switch Corporation

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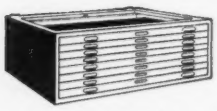
Branches: 43 East Ohio St., Chicago • 11 Park Place, New York City • Sales and Engineering Offices: Boston, Hartford, Los Angeles

TO THE RESCUE—
SOMETHING NEW IN FILES

BRUNING-HAMILTON VICTORY WOOD FILING UNITS

WAR multiplies your tracings and prints—but subtracts filing space. Today, when steel files have gone to war, there is a complete answer to wartime filing needs . . . the new Bruning-Hamilton Victory Wood Filing Units. Here's what they offer you—



8-drawer unit

5-drawer unit

***Interlock with steel units**—Bruning-Hamilton Victory Wood Filing Units interlock and stack with corresponding sizes of steel units.*

***Look like steel**—Styled and finished in the same olive green as standard steel units.*

***Smooth, quiet action**—Thanks to roller drawer construction.*

***Patented tracing lift**—To make filing easy—to eliminate danger of creasing or crumbling—available for 8-drawer units.*

***Pantasote dust covers**—Available in 5-drawer units—protect plans from dust—minimize wear.*

***Safety drawer stops**—Keep file unit drawers from being pulled out accidentally. Drawers cannot be slammed shut.*

***Efficient locking device**—Keeps your plans confidential. File unit cap also locks.*

Bruning-Hamilton Victory Filing Units are sponsored by Bruning—famous since 1897 for quality in sensitized papers and cloth, drafting and engineering supplies. Write for free illustrated folder on Bruning-Hamilton Victory Wood Filing Units. Charles Bruning Company, Inc.

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SINCE 1897
NEW YORK • CHICAGO • LOS ANGELES
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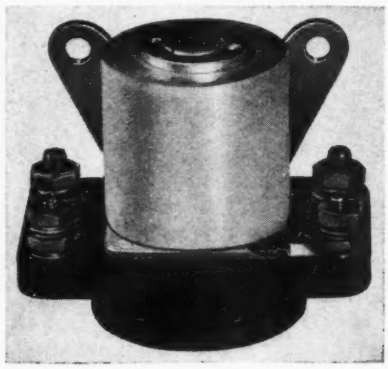
and like the other cores that are available in practically every type for frequencies up to 50 megacycles, the new units are outstanding for their uniformity.

Contactor for Aircraft Control

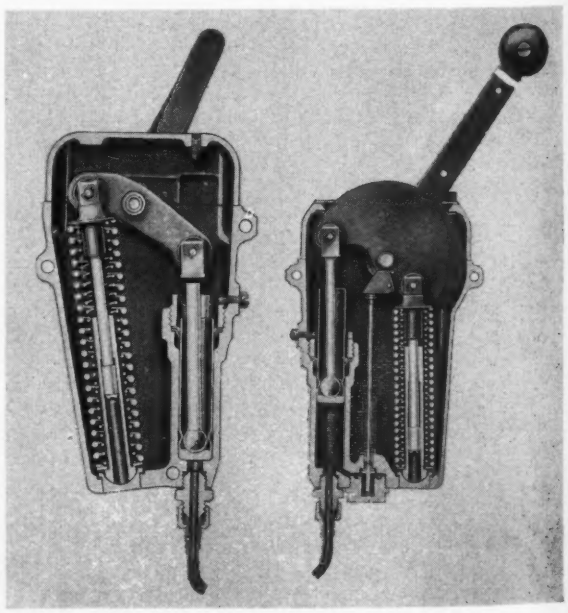
BUILT to U. S. Army Air Force specifications, the new B-5 solenoid contactor, announced by Guardian Electric Mfg. Co., 1601 West Walnut street, Chicago, can be adapted for numerous applications of heavy current control in aircraft and other fields. It has a contact rating of



50 amperes continuous and operates on 24 volts direct current, producing a coil current of 210 milliamperes. Double-pole, single-throw with normally open contacts, the contactor weighs 11.2 ounces. The unit operates in any position and is so constructed that it may be disassembled with pliers and screwdriver. Metal parts are plated to withstand 200-hour salt spray test.

Exactor Hydraulic Control

ANNOUNCED by Sperry Products Inc., 1505 Willow avenue, Hoboken, N. J., the new 300 exactor hydraulic control consists of two units—a transmitter fitted with a handle and a receiver which delivers through its lever motion imparted to transmitter handle. The only



A page from Experience

TO HELP YOU NOW AND IN THE FUTURE

CMP PRECISION COLD ROLLED STRIP STEEL SPEEDS PRODUCTION AND LOWERS COST IN WIDE VARIATION OF REQUIREMENTS . . . . . .

The wide range of physical properties available in CMP strip makes it adaptable for many products where speed and cost are vital factors. Wartime requirements for light gauge metals have particularly proven the broad potentialities of CMP precision strip—it is successfully serving in many cases where precedents ruled it neither feasible nor practical. Result—increased essential production, faster fabrication and lowered cost. Better check on CMP strip—you will want the interesting facts for post-war product plans too.

THESE ADVANTAGES HAVE PROVEN OF IMPORTANT VALUE TO MANY VITAL WAR INDUSTRIES . . . .

CONTROLLED UNIFORMITY

Consistent accuracy and uniformity are certain with CMP strip. Vigilant guard and precise control methods assure duplication of all desired properties in coil after coil—you get steel precision fitted to the job.

COILS UP TO 300 LBS. PER INCH OF WIDTH

Where automatic machines are utilized, work delays can be minimized. Normally CMP strip can be supplied in coils up to 300 lbs. per inch of width—keeps presses productive for long periods without interruptions—a real help for high speed production.

REPLACING NON-FERROUS METALS

Many new and important applications of CMP strip involved the change from light gauge non-ferrous metals. These cases were successfully accomplished by meeting essential physical characteristics of metals formerly used.

MORE FEET PER POUND

You get the most out of each vital ton with CMP strip. It is the CMP custom of rolling to exceptionally close tolerances, whether specified or not, that provides maximum feet per pound and thus more finished parts per ton—a CMP advantageous "extra."

THE COLD METAL PRODUCTS CO.

SUBSIDIARY OF THE COLD METAL PROCESS COMPANY

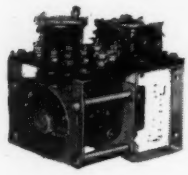
YOUNGSTOWN, OHIO

CMP PRECISION COLD ROLLED STRIP STEEL

for

MAXIMUM PRODUCTION PER TON

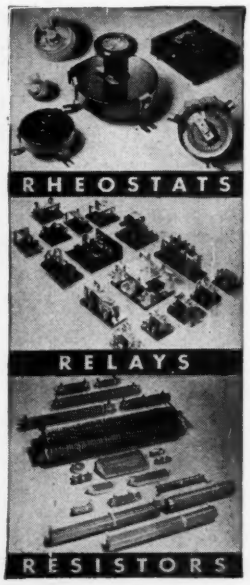
Battleship U.S.S. Texas firing main battery broadside, U.S. Navy Official Photo



IT'S IN THE NAVY NOW

WE can tell you about this motor driven, time delay relay because it has been used for years in peace time activities as a time control in drying systems, heat treating ovens, illumination and many other applications.

Now it's in the Navy. The positive action, ruggedness and resistance to shock and vibration of this relay, make it ideal for alarm control, communication circuits and for the protection and timing of many kinds of equipment aboard ship. Manufacturers who are doing essential war production can often find items in the regular line of Ward Leonard Controls that will serve their needs without the delay of extensive redesigning.



WARD LEONARD

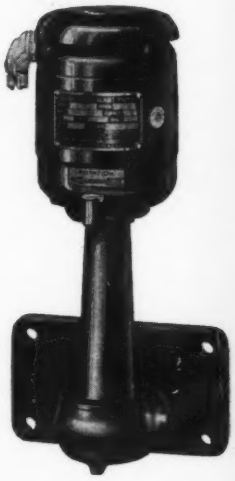
Electric control (WL) devices since 1892.

WARD LEONARD ELECTRIC COMPANY
58 SOUTH ST., MT. VERNON, NEW YORK

connection between transmitter and receiver is a single tube which can be bent to pass intervening objects such as flexible connectors. To prevent leakage, cylinders are fitted with trunk-type pistons and special packing glands. Interconnecting tubing and cylinders form a closed system which is filled with a low-freezing liquid. To correct the occasional variation in the starting position of the transmitter handle, caused by oil leakage in the system or changes in volume of oil resulting from extreme temperature changes, a means for synchronizing the control is provided. A tripper lever opens the valve venting the system into the oil reservoir, permitting any deficiency of oil to be replaced or any excess to be exhausted. On suction stroke the control will deliver 100 inch-pounds of torque (equivalent to 85 inch-pounds of linear work); and on pressure stroke, 2 to 3 times this amount.

Gusher Coolant Pump

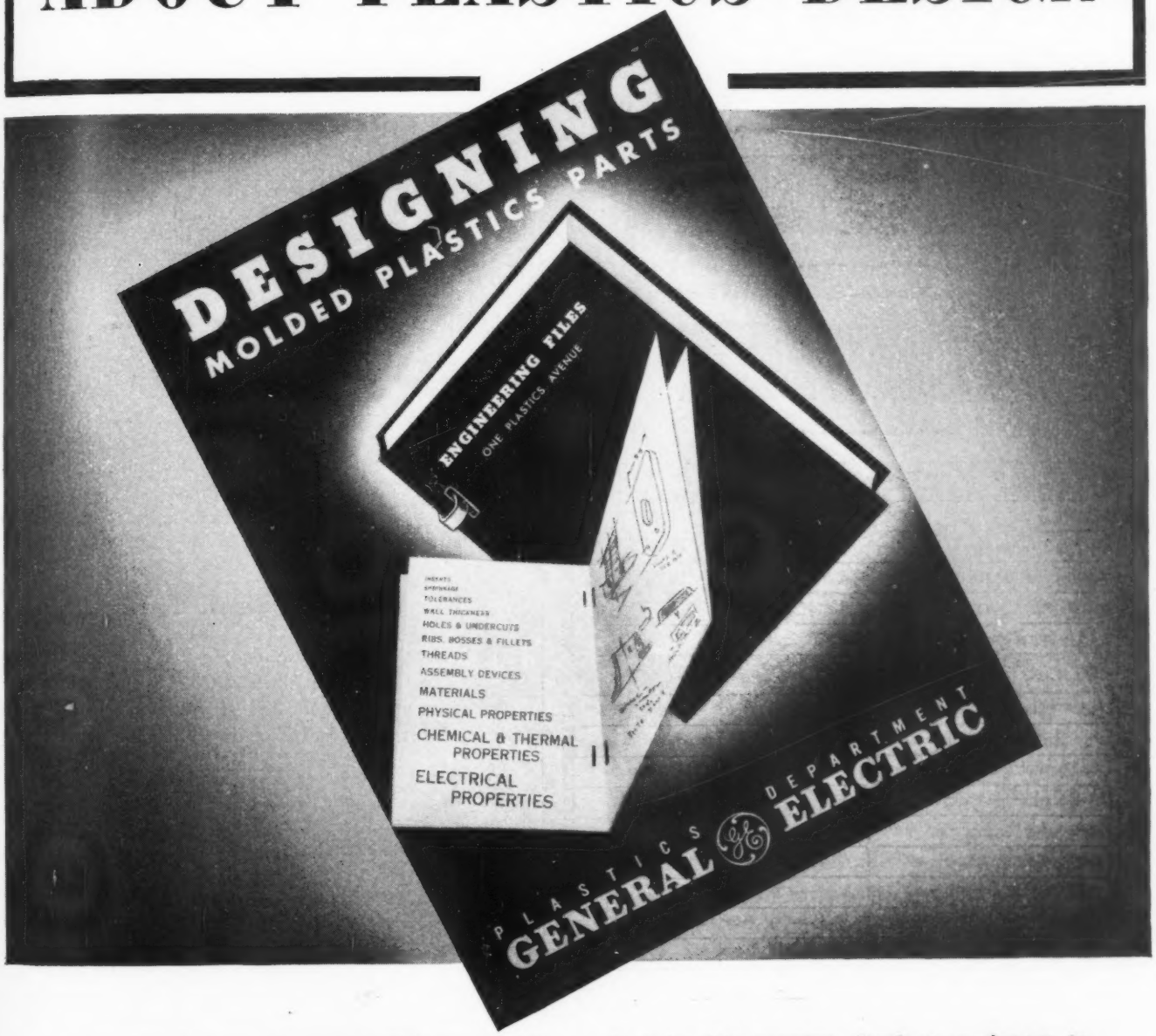
MOTOR-DRIVEN gusher coolant pump recently developed by The Ruthman Machinery Co., 1819 Reading road, Cincinnati, is a vertical 1/10 horsepower pump known as Model 5-P3. The discharge opening is available either to the right or left. Capacity of the pump, through ½-inch pipe at 5-foot head, is 10 gallons per minute. Impeller housing and mounting flange are cast in one piece. Mounting is larger in order to be interchangeable with larger size gusher pumps — namely, Models 11022, 11020C and 11022E — to meet possible change in working conditions or in the type of machine production. This applies to installation on new machine tools as well. Driving motor is a full ball bearing type with one-piece suspended shaft to the pump housing. Packing and metal contacts are eliminated. Seal between motor and pump is by "lubri-sealed" ball bearings in direct conjunction with a centrifugal slinger. Impeller used is the company's twin equalized intake type, accomplishing hydrostatic balance. This feature automatically cleans the intake chambers when discharge line is throttled, and acts as an automatic by-pass which prevents building up pressure. Mounting is simple, requiring only four cap screws and a communicating gravity inlet.



Nonmagnetic Manganese Alloy

FREEING nickel, chromium and tin for other war uses, a new magnetic manganese alloy manufactured by General Electric Co., Schenectady, N. Y., has been developed as a substitute for 18-8 stainless steel. Because either alloy requires a covering to permit soldering, lead

FOR MEN WHO NEED TO KNOW
ABOUT PLASTICS DESIGN



Here—in a new 16-page bulletin—are the latest facts about designing molded plastics parts. This information has been prepared by General Electric Engineers who form the expert engineering staff of One Plastics Avenue, where stands the largest plastics molding plant in this country. Product engineers to whom we have shown this new bulletin declare that it is indispensable for men working with plastics. For copies write Section E-1, Plastics Department, General Electric Company, One Plastics Avenue, Pittsfield, Mass.

PLASTICS DEPARTMENT
GENERAL ELECTRIC

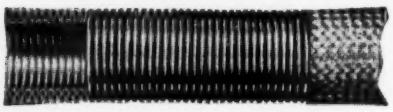
FLEXPEDITE

Your Conversion—Assembly—Production

with

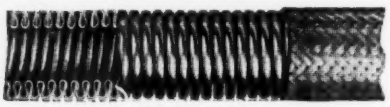
REX-WELD
Flexible Metal Hose

Rex-Weld Hose—Annular Corrugations



RW-50 Unbraided ——— RW-51 Braided

Rex-Weld Hose—Helical Corrugations



RW-50 Unbraided ——— RW-51 Braided

—General Data—

	STEEL	BRONZE
Sizes	To 4" I.D.	To 4" I.D.
Pressures	To 14,500 p.s.i.	To 14,500 p.s.i.
Temperatures	To 1000° F.	To 450° F.
Lengths	To 50′	To 50′

—Use Chart—

	*STEEL	BRONZE
Saturated Steam		✓
Superheated Steam	✓	
Sulphur Bearing Oil	✓	
Oxygen		✓
Ammonia	✓	
Carbon Dioxide	✓	
Sulphur Bearing Grease	✓	
Critical Vibration		✓
Non-Sparking		✓

Protective Coatings Can Be Applied for Corrosion Protection (To Conserve Critical Copper Bearing Alloys).

Couplings: REX-TITE Mechanical (Re-attachable) Couplings; Solder Couplings; Brazed and Welded Couplings and Flange Assemblies for Rex-Weld Flexible Metal Hose.

Ask for Engineering Recommendations

CHICAGO METAL HOSE CORPORATION

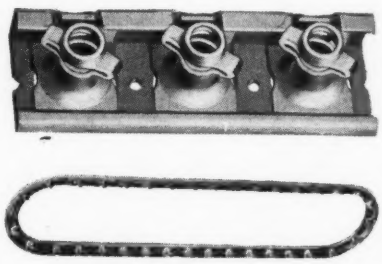
General Offices: MAYWOOD, ILLINOIS

Factories: Maywood and Elgin, Ill.

has been substituted for the tin coating previously used. The new alloy is expected to remain in general use when the war ends and chromium, nickel and tin again are available. Bars, rods and plates of the new alloy are used in motor-generators for submarines, control equipment for planes and tanks, and in switchgear equipment and motors for war industry generally. Wire of the alloy has wide application, chiefly in electric locomotives.

Nuts in Fabricated Shapes

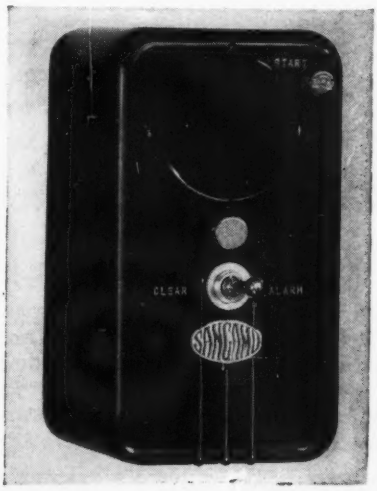
CHANNEL and circular channel nuts in factory fabricated shapes can be supplied by Boots Aircraft Corp., New Canaan, Conn. In the accompanying illustration is shown one of the oval pieces now made for a specific inspection port. It is one of three similar



applications used on the Curtiss C-46 planes. Being jig-made in the factory, it gives assurance of matching application, making assembly easier. Cutting down appreciably on the number of rivet holes required is another outstanding advantage.

Air Raid Siren Timer

PROVIDING automatic coding for air raid warning signals, Sangamo Electric Co., Springfield, Ill., is offering its new Model LLH siren timer, designed as a simple, dependable means of controlling air raid warning



signals. Pure silver contacts are rated at 5 amperes on 115 volts or 2½ amperes on 230 volts, alternating current. On larger loads, the timer should be connected to control the coil of a magnetic motor starting switch. The stand-

HERE'S WHAT LYON OFFERS
War Plants Seeking More Sub-Contract Production
1. Aircraft: Capacity available in Aircraft Division for aluminum parts and sub-assemblies.
2. Sheet Steel: 42 years experience in fabricating steel—over two years on special war products.
3. Ships: Experienced Lyon Engineers are working daily with architects and ship builders on pre-fabricated parts and furniture.
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5. Know-How: Experienced development, design and engineering staffs. Complete toolrooms in all plants. Send for book, "Craftsmen in War Production."
LYON METAL PRODUCTS INCORPORATED
General Offices:
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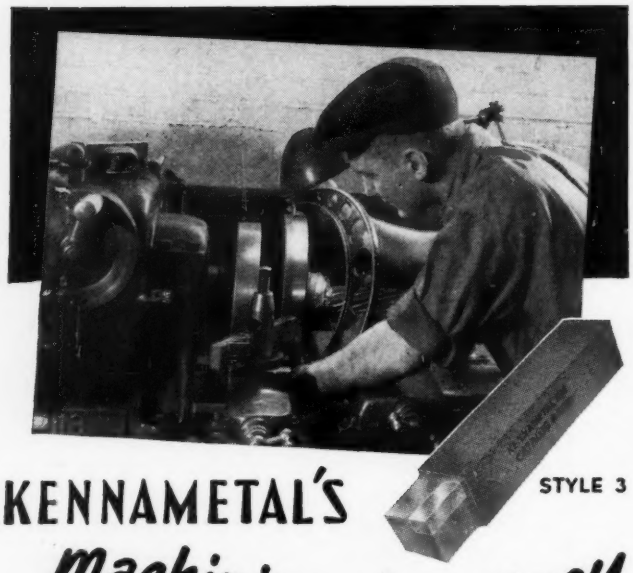


KENNAMETAL'S STYLE 3

Machining Accuracy

MINIMIZES ABNORMAL WEAR

KENNAMETAL'S ability to cut steel and alloys to extremely close tolerances, and to leave a very fine finish, is the answer to new machining problems arising from the introduction of new alloys as well as higher production demands.

High tensile steels represent distinct problems in metal cutting. This is especially true in the aircraft industry where extreme accuracy and freedom from warpage are required on all parts.

Bar and tube stock as well as forgings are machined after heat treatment. These hardened steels demand a hard cutting tool to keep up spindle speeds, and a very strong tool cutting edge to economically machine these parts. KENNAMETAL'S ability to "hold size" saves frequent adjusting of stops and permits long cuts to be made without appreciable taper from tool wear.

The bright smooth surface obtained with KENNAMETAL tools eliminates torn or burred surfaces. This is critical since torn surfaces are ideal places for cracks to start when parts are under high stresses, hydraulic pressure, and vibrations.

Increase the number of "passed" inspected parts by machining these high Brinell steels with KENNAMETAL — KENNAMETAL'S machining accuracy eliminates repairs by minimizing wear on working parts.

Write for the new McKenna Metals Company catalog, No. 43.

KENNAMETAL THE All American CARBIDE

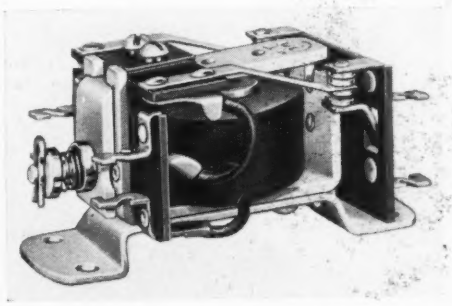
McKENNA METALS Co.

146 LLOYD AVE., LATROBE, PA.

ard contact operation for the alarm signal is 5 seconds closed, 3 seconds open, continuing for two minutes. If specified, 7 seconds closed, 6 seconds open, will be furnished. Siren timers for operation from a distant point by means of pushbuttons can also be provided. This latter type is known as Model 3-61H3R, for 115 volts and 60 cycles.

Remote Control Relays Offered

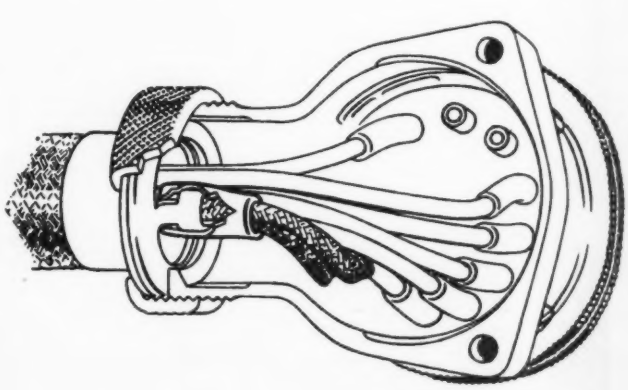
ADAPTED to applications within their ratings where space is limited, small compact remote control relays announced by Ward Leonard Electric Co., Mount Vernon, N. Y., are available for operating on alternating or direct-current circuits. Standard relays are of open type with front-connected, solder type terminals and double-pole, double-throw, silver-to-silver contacts. The



contacts are rated 4 amperes up to 24 volts alternating or direct current, and 4 amperes alternating current, 1 ampere direct current from 25 to 115 volts. These relays are vibration resistant up to ten times gravity in the energized position. Overall height is 1¼-inch.

Bonding Ring for Aircraft

USED wherever there is a need for bonding between electrical plug shell and wire shielding, or with either flexible conduit coupling nut or cable clamp, a new bonding ring has been offered by The Cannon Electric Development Co., 3209 Humboldt street, Los Angeles.



The ring at the present time is used almost exclusively in bonding shielded radio and instrument circuits in aircraft applications, but is adaptable to many other requirements where a tight bond is needed. The ring fits a variety of conduit nuts.

What Pump Can Handle *This?*

It's "ceramic slip" for spark plug insulators, one of the hardest-to-pump, most abrasive materials known. Read how the Champion Spark Plug Company solved this tough problem by using the *R & M Moyno Pump!*

"We are pleased to report that our R & M Moyno Pumps are giving satisfactory service. From our experience we have concluded that they have definite advantages over other pumps we have tried.

"Our spark plug insulator body is highly abrasive, and pumping such a slip is a very difficult undertaking. Repairs to our Moyno units have been held to a minimum, and due to the easy accessibility of all parts, only short shut-down periods are necessary for replacing worn parts."

Norman C. Shimman, Assistant Superintendent at Champion's Ceramic Division, with one of their Moyno units. His left hand rests on the rotor and stator assembly while he explains how the Moyno elevates abrasive slip *40 feet* to the second floor—eliminates harmful bubbles, increases production and reduces "pumping trouble" delays and maintenance to an all-time low.

Do you have a *tough* pumping problem? Then now's the time to investigate the R & M Moyno! Whether your problem is handling a high-pressure gun-boring coolant, a corrosive chemical, an abrasive material like Champion Spark Plug's "insulator slip," or almost *anything* that will flow through a pipe, the R & M Moyno Pump can probably solve it just as it has whipped countless "impossible" pumping problems.

The Moyno is a *revolutionary* pump. It eliminates piston and valve wear because it has *no* pistons or valves. Cavitation and pulsation are also eliminated because the Moyno always provides constant, uniform flow. Even maintenance time and labor are drastically reduced, for the Moyno is so accessible that it can be completely dismantled and reassembled in 30 minutes or less. And finally, the Moyno is so compact and simple in design that it is easily installed in the plant or mounted on the machine it serves.

Many designers and product engineers are now specifying the R & M Moyno Pump as original equipment on their machines, while production engineers in many industries are adapting it as a proved method of increasing output and improving quality. Write for complete information today!

ONLY 1 MOVING PART!

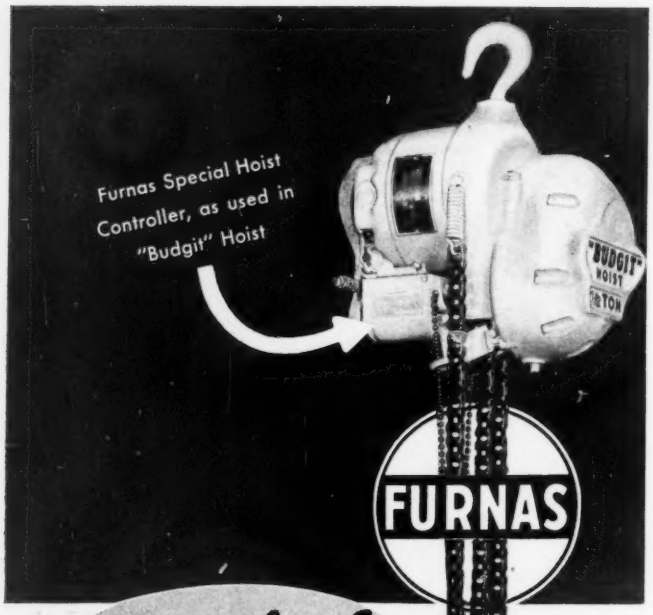
Here's the patented principle of the R & M Moyno Pump's amazing performance. A single-threaded helical rotor revolves within a double-threaded helical stator, providing pumping action like that of a piston moving through a cylinder of infinite length.

ROBBINS & MYERS • Inc.

MOYNO PUMP DIVISION — **SPRINGFIELD, OHIO**

In Canada: Robbins & Myers Co. of Canada, Ltd., Brantford, Ont.

HOISTS • CRANES • MOTORS • MACHINE DRIVES • FANS • FOUNDED 1878



Special FURNAS CONTROLLERS

DESIGNED TO DO UNUSUAL JOBS

★ If you do not find exactly the right Drum Controller in the complete Furnas line to meet some difficult or complicated controller requirements, put your problem up to our engineers. Based on their many years of specialized controller experience, they will design a special controller that we will build to fill your specific need—just as for example, we designed and built a special Drum-Hoist Controller for the Manning, Maxwell & Moore popular "Budgit" Portable Electric Hoist illustrated above.

Investigate Furnas Drum Controllers

★ Furnas Drum Controllers are made in all types and in sizes from ¼ to 10 H.P. Write for the 16-page Free Booklet listing and describing Furnas Drum Controllers, also Furnas magnetic switches, limit switches, pressure switches, foot switches, etc. Furnas Electric Company, 439 McKee Street, Batavia, Illinois.

WEATHERPROOF DRUM CONTROLLERS The mechanism is totally enclosed by a cast iron top and steel tank. Suitable for installation wherever dust, grit, fumes or moisture are present. Oil-filled type is provided with filler plug and gage rod.

MASTER SWITCHES Cam operated for traveling cranes; operate contactors and magnetic switches to short circuit secondary of wound rotor induction motors. 5 speeds forward and 5 reverse.

FURNAS ELECTRIC COMPANY

SPECIALISTS IN DRUM CONTROLLERS

BATAVIA ILLINOIS

ASSETS to a BOOKCASE

The Marine Power Plant

By Lawrence B. Chapman, Professor of marine transportation and marine engineering, Massachusetts Institute of Technology; second edition, published by McGraw-Hill Book Co. Inc., New York; 401 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$4.00 postpaid.*

Intended as an introduction to marine engineering, this book is chiefly concerned with the overall picture and with fundamental principles, including thermodynamics and economic features. While descriptive matter and details have been kept to a minimum, those that are included have been carefully chosen for their value in making clear the principles involved. They also provide the reader with an excellent comprehension of the wide variety of present-day propelling machinery types.

Following the earlier chapters on fuels, boilers and combustion, the chief machinery types are discussed in turn—the reciprocating steam engine, the geared turbine, the turboelectric drive and the diesel engine. This is followed by a chapter comparing the different types. Condensers and auxiliaries, feed-water heating, feed-water systems, and power plant layouts are then covered, the chapter on power plant layouts being noteworthy for the typical machinery arrangement plans of modern ships. In the final chapter computations are worked out in detail for the power plant of a modern turbine-driven merchant ship.

□ □ □

Alternating-Current Machines

By A. F. Puchstein, Consulting Engineer, Celanese Corp. of America, and T. C. Lloyd, Chief Engineer, Robbins & Myers Inc.; second edition, published by John Wiley & Sons Inc., New York; 655 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$5.50 postpaid.*

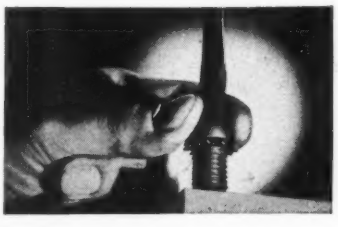
As a comprehensive text and reference this book is recommended to design engineers whose work involves applying alternating-current machines. While the scope of the work includes construction and design, of greater interest to the general machine designer will be the quantitative discussions of operating characteristics of the various types of machines. In necessarily limiting the scope of the book, the authors have confined themselves to steady-state phenomena, with the exception of certain important aspects of synchronous motor performance.

Taking advantage of the recent adoption of new methods of analysis, the authors have in the second edition completely rewritten the sections on alternators and synchronous motors. Progress in standardizing ratings, machine dimensions and characteristics is also reflected in the new edition.

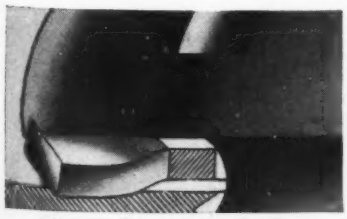
This Unit *Saves Man-Hours!*

Pre-assembled SHAKEPROOF Lock Washer and Screw... handles as a single unit...speeds assembly operations!

NO TIME WASTED DOING THIS!



EASY TO HANDLE FASTER DRIVING!



EVERY SCREW LOCKED TIGHT!

● SEMS Fastener Units have proven their outstanding production advantages in hundreds of war equipment applications. Because they are pre-assembled, they eliminate the time formerly required for putting the lock washer on the screw. "Green" workers can handle them easily and there is no chance to "forget" the lock washer. SEMS units not only speed up assembly but also assure positive locking for every screw—an important factor in quality control. Write for free testing samples today!

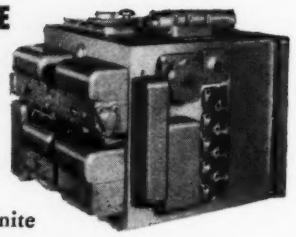
SHAKEPROOF inc.
"Fastening Headquarters"

2501 North Keeler Avenue, Chicago, Illinois
Distributor of Shakeproof Products Manufactured by ILLINOIS TOOL WORKS
Plants at Chicago and Elgin, Illinois
In Canada: Canada Illinois Tools, Ltd., Toronto, Ontario

SEMS FASTENER UNITS

How to Get More Machines, Skilled Machinists and Floor Space

DESIGN OR REDESIGN YOUR MACHINES TO USE THESE UNIT-TYPE HYDRAULIC FEED TRANSMISSIONS . . .



In addition to obtaining an infinite feed range and improving the performance of your machine, you can benefit in three different ways by using Barnes Unit-Type Hydraulic Units.

RELEASES MACHINES FOR OTHER WORK

If you are using a large part of your machinery to cut gears, splines and cams, and to mill, drill and bore mechanical feed transmission housings, you can convert this equipment to other work—***increases your productive capacity.***

RELEASES SKILLED HELP FOR OTHER WORK

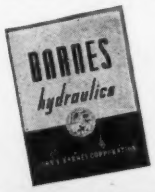
Your highly skilled men now working on the precision machine tools used in manufacturing mechanical feed transmissions, can be used on other precision work in your plant—***improves your skilled manpower position.***

PROVIDES ADDITIONAL FLOOR SPACE

All of the floor space now holding equipment used for the manufacturing of mechanical feed transmissions will be used for other manufacturing—***increases your plant capacity.***

TWO METHODS AVAILABLE

Complete hydraulic circuits can be furnished as panels or units for metal working machines. A Barnes self-contained hydraulic unit, as shown above, is furnished with necessary pumps and valves to complete the hydraulic functions of your machine. Hydraulic oil reservoir is included. Providing cylinder space in your machine design and connecting two pipes to each cylinder constitutes your total hydraulic effort. A Barnes Panel Unit is similar to the self-contained unit except provision must be made in the machine for oil reservoir. For complete information write for the booklet offered below.



FREE DATA:
40 page booklet contains detail descriptions of all Barnes elements and typical installation circuits. Write for your copy today. Ask for bulletin M.D. 143.

John S. Barnes Corporation

DETROIT SALES OFFICE
503 NEW CENTER BLDG.
TR-1-1706

MAIN OFFICE AND FACTORY
ROCKFORD, ILL.

How Industrial Truck Meets Needs

(*Concluded from Page* 76)

rides up on a felt pad mounted on the piston end. Because the slide length only need be doubled to supply a guide for the fork travel, it travels at the piston rate, half that of the fork. In the design illustrated, the piston head casting has four through rods, spring mounted to the cross head of the telescoping slide. This spring mounting is not visible in *Fig.* 5, but the welded spring cup ends may be seen on the two rods on the back side. These rods assist in holding the piston head central and, when the lift is being lowered, serve a definite purpose in preventing the slide from remaining in the elevated position and dropping suddenly after piston has started to return. In other words the piston head cannot move downward with respect to the slide beyond the bolts on the rod ends without starting the return of the slide.

Because time and space are at a premium in production plants and because armaments and military supplies must be moved rapidly, the effects of compact, highly maneuverable trucks of which this design is typical can readily be seen.

Proves Striking Power

FLYING Fortresses with protective cover of Lightnings are striking the Axis at longer range than would be possible for any other combination of fighter and bomber. The outstanding effectiveness of Lightnings as bomber cover over France, Germany, Tunis and the Southwest Pacific has been proved by the disinclination of the enemy to come up and fight. Thus far, this combination of planes is second to none.

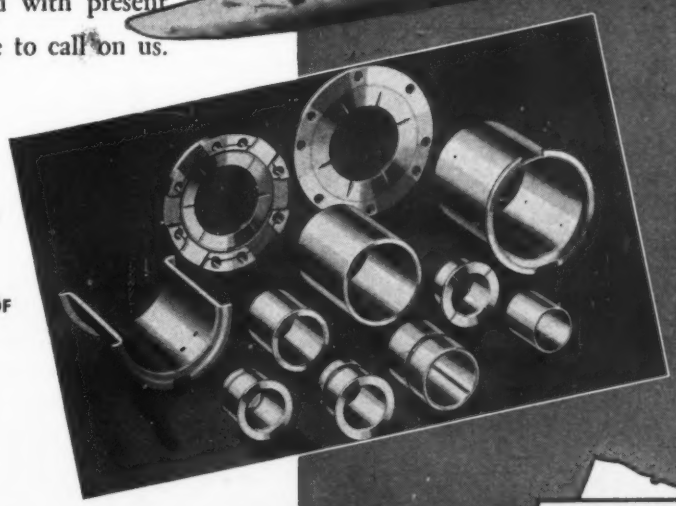
NO INTERNAL DISSENSION HERE

Clutch and Valve "Harmony" Is Machined from OHIO SEAMLESS TUBING

● Even in quiet flight formation every part of the operating mechanism must do its intended duty surely and continuously. At some of the most vital spots in many types of fighting aircraft, this wear-and-tear responsibility is shouldered by a partnership between OSTUCO Tubing and accurate machining and finishing.

Two such vital parts are valve rocker shaft bushings and high ratio clutch gear bearings. Beyond meeting strict Army and Navy specifications, special care is taken in drawing and treating the tubing to provide properties which help in later operations. For this reason Ohio Seamless Tubing has earned a remarkably consistent record of low rejection percentages over a long period of years.

OSTUCO is acquiring brand-new experience through its manufacture of seamless tubing from new steels, to new specifications, for never-before applications in machines designed for offensive action on land, sea and in the air. If this experience can help you with present problems or long-range planning, be sure to call on us.



MACHINED AIRCRAFT PARTS FINISHED FROM OHIO SEAMLESS TUBING. (PHOTO COURTESY OF CLEVELAND GRAPHITE BRONZE CO.)

THE OHIO SEAMLESS TUBE COMPANY

SHELBY OSTUCO OHIO

PHOTO COURTESY OF U. S. NAVY DEPT.

CHERRY BLIND RIVETS

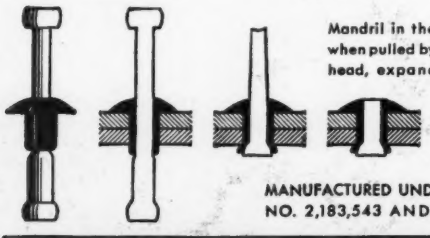
need no bucking bar, have positive mechanical action

Cherry Blind Rivets are made to save time in the hard-to-get-at spots. The riveting is done by one man from one side of the work. There is no time-consuming reaching through inaccessible structures because no bucking bar is needed. Self-plugging Cherry Rivets can be applied at the rate of 800 per hour . . . the hollow type at 1600 per hour.

The G-15 Power Gun, as shown here, is the most efficient tool for Cherry Rivet application. The G-10 Hand Gun may be used when compressed air is not available.

HOW HEAD IS FORMED—The Cherry Rivet is a true rivet, made of aluminum alloy, through which passes a double-headed mandril. Riveting is done with either a hand-operated or power gun which pulls on the mandril and pushes on the rivet head. The mandril forms a tulip head on the blind side, expands the shank and permanently plugs the rivet.

NO CRITICAL TOLERANCES—The positive mechanical action of the Cherry Rivet gives satisfactory performance with reasonable tolerances in grip length and hole size. This characteristic makes them highly practical for field service and repair work as well as for new aircraft structures. Complete instructions on the use of Cherry Rivets will be furnished on request.



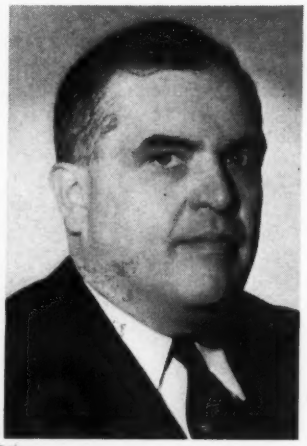
Mandril in the self-plugging Cherry Rivet, when pulled by Cherry Rivet Gun, forms tulip head, expands rivet shank, permanently plugs the rivet and then breaks, releasing the gun. Mandril is trimmed flush.

MANUFACTURED UNDER UNITED STATES PATENT NO. 2,183,543 AND OTHER PATENTS PENDING

Cherry Rivet
Company
LOS ANGELES, CALIFORNIA

MEN OF MACHINES

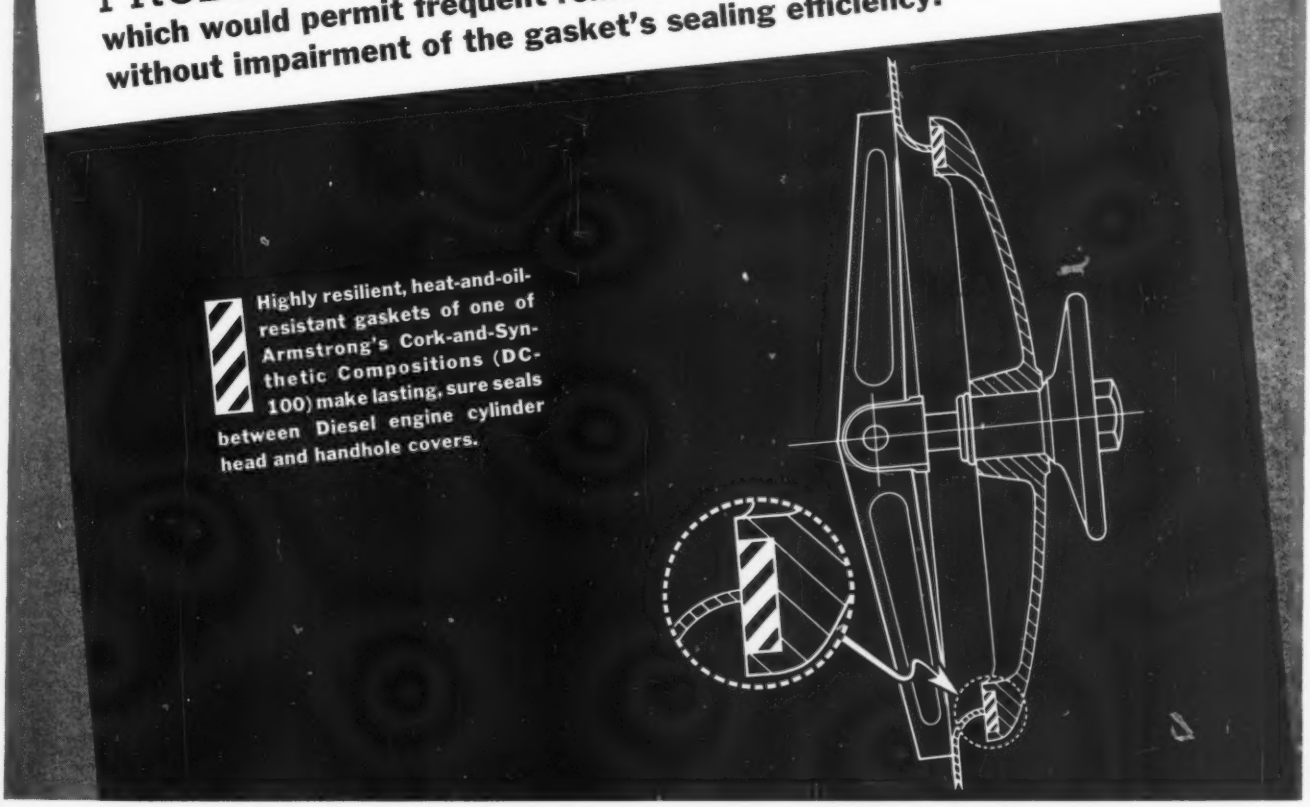
RECENTLY announced was the appointment of Charles Nelson Jr. as chief engineer of the Ahlberg Bearing Co., Chicago. He will be in charge of the company's bearing design and development work. After receiving his educational training at Lewis and Armour institute of Chicago, he joined the engineering staff of Marlin-Rockwell Corp. He remained with this organization until 1931 at which time he joined the Ahlberg company. In 1933 he was appointed assistant chief engineer which position he occupied until his recent advancement. During his connection with Ahlberg, Mr. Nelson has been responsible to a large extent for the development of the CJB line of ball bearing pillow blocks and other units designed for industrial application.



IN HIS new appointment as vice president and chief engineer of RCA Mfg. Co., Camden, N. J., Dr. Charles Byron Jolliffe will be able to contribute greatly to the industry with his valuable engineering experience in the fields of radio and electronics together with his outstanding qualifications as an administrator at a time when the company is geared to all-out wartime production. He formerly was assistant to the president of Radio Corp. of America and chief engineer of RCA Laboratories. Born in 1894, Dr. Jolliffe was graduated from West Virginia university with a bachelor of science degree in 1915, and master of science degree five years later. In 1942 he

CASE HISTORY No. 207 FROM OUR GASKETS FILE

PROBLEM: To find a Diesel engine handhole cover gasket which would permit frequent removal and replacement of the cover without impairment of the gasket's sealing efficiency.



Highly resilient, heat-and-oil-resistant gaskets of one of Armstrong's Cork-and-Synthetic Compositions (DC-100) make lasting, sure seals between Diesel engine cylinder head and handhole covers.

A MANUFACTURER of Diesel engines needed better handhole cover gaskets. The ones he'd been using sealed efficiently enough, but would usually stick and often break when the handhole covers were removed. Inasmuch as the covers are removed and replaced frequently, this disadvantage was a real nuisance.

The gasket material desired was one which would (1) tightly seal lubricating oil inside the engines; (2) resist the deteriorating effects of the oil; (3) withstand the relatively high operating temperatures of the engines; (4) retain its sealing efficiency despite frequent removal and replacement of the covers.

Solution

When this problem was presented to Armstrong's sealing specialists, they suggested one of Armstrong's Cork-and-Synthetic Compositions, DC-100. The cork in this composition assures true compressibility with permanent resilience for sure sealing. The composition has the necessary resistance to oil and successfully withstands the engine heat. DC-100 was adopted for sealing the engine handholes and has been giving satisfactory service ever since.

Rolls, Sheets, Gaskets, Molded Parts

The solution to *your* sealing problem may likewise be found among the more than fifty efficient sealing materials Armstrong makes. These include cork, synthetic, cork-and-synthetic, and cork-and-rubber compositions; No. 841 Fibrated Leather; and rag felts. Armstrong's Compositions having virtually any desired physical properties are available in rolls and sheets, in molded shapes, cut gaskets, and extruded rings. Write today for your free copy of the booklet describing Armstrong's Gaskets, Packings, and Seals. Armstrong Cork Company, Industrial Division, 5101 Arch Street, Lancaster, Pennsylvania.

ARMSTRONG'S
GASKETS · SEALS
PACKINGS

Rubber-like Synthetics
*Cork-and-Synthetics • Cork-and-Rubber
Cork Compositions • Fibrated Leather

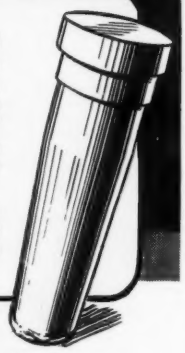
*FORMERLY "CORPRENE"

OUTPUT per punch UP 250%

CASE J143

Expanding punches of Ampco Metal Grade 20. Previously used steel. Nickel molybdenum rings 2.62" OD x 1.355" ID x 36" long were expanded to 2.95" OD x 1.91" ID.

Result: maximum run of 3000 rings using steel increased to 10,500 using Ampco Metal.



AMPCO Expanding Punches Have Longer Life

Again "Ampco" bronze proves its worth —this time in expanding punches. Here centrifugally cast Ampco Metal Grade 20 was used to expand nickel molybdenum rings, increasing OD .35" and the ID .553". Service life of Ampco punches was 3½ times that of hardened steel.

Ampco Metal Grade 20 has the necessary hardness—212-248 Brinell for this application. Its strength and resistance to high compressive loads are other necessary factors in successful service. As many engineers know, it is the only copper base bearing alloy with these requirements. By using Ampco, you avoid metal weakness, failure and frequent replacement.

Ask for Data Sheet 100, describing the use of Ampco Metal in expanding punches.

AMPCO METAL, INC.

Department MD-1 **Milwaukee, Wis.**

AMPCO METAL

AMPCO

THE METAL WITHOUT AN EQUAL

received the LL.D. honorary degree from his alma mater. When an instructor in physics, from 1920 to 1922, at Cornell university, he received his Ph.D. At this time he joined the Bureau of Standards and served as a physicist in the radio section until 1930. He left this post to accept the appointment of chief engineer of the Federal Radio commission, the position he held under the Federal Communications commission in 1934. A year later he resigned this position to join the engineering staff of the Radio Corp. of America as engineer in charge of the RCA Frequency Bureau. In 1941 he was appointed chief engineer of RCA Laboratories, and early this year, assistant to the president of RCA. Dr. Jolliffe has attended many international radio conventions as U. S. delegate and technical advisor. At the present time he is serving on several government wartime committees that pertain to radio communications and research.

♦

EMIL HEMMING JR., son of the president of Plastics Products Inc., South Norwalk, Conn.; ROBERT GOLDSMITH, formerly of the University of Nebraska; and WILLIAM RENWICK of New York, a Princeton graduate, have recently graduated from the Plastics Industries Technical institute and have received civil service appointments as junior plastics technologists at the Naval Aircraft factory, Philadelphia. Research and development work in application of plastics for aircraft are centered at this plant.

♦

ELDON M. WILSON is the new chief engineer of the recently announced Century Engineering Co. Mr. Wilson was formerly connected with North American and Northrop aviation companies.

♦

J. M. LUTHER has been made assistant chief engineer at Globe Aircraft. Before accepting this position, Mr. Luther did design work for Curtiss-Wright, working on the company's P-40 series as well as on the Hell-Diver and Sea Gull. Prior to this he had been associated with the engineering staffs of Vultee, North American and Lockheed companies.

♦

WALLACE D. KIMBALL of Standard Knapp Corp., has been appointed president for 1943 of the Packaging Machinery Manufacturers institute. H. KIRK BECKER of Peters Machinery Co., and KENDALL D. DOBLE of Pneumatic Scale Corp., are vice presidents.

♦

L. P. WHEELER has been elected president of the Institute of Radio Engineers. He has been head of the engineering department, information division, Federal Communications commission. Formerly he was superintendent of the consultant division of the Naval Research laboratory.

♦

EDWIN H. BROWN has been named assistant chief of the WPB iron and steel branch, in charge of plant facilities section. Mr. Brown was engineering vice president of Allis-Chalmers Mfg. Co. FORREST NEGLER, chief mechanical engineer, will be in charge of the company's engineering and development department during Mr. Brown's absence.

♦

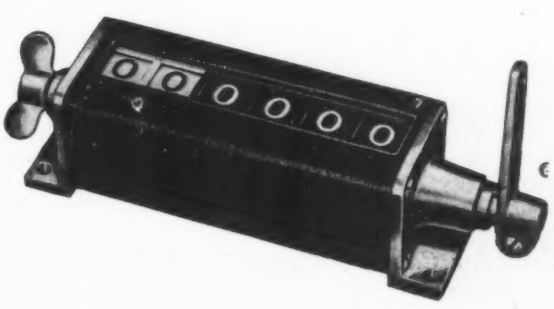
HERMAN C. FRENTZEL, chief engineer, and CHARLES G. EISENBERG, chief of the body and hoist division of the

What your machines could do with built-in Bull Fighters!

It's easy to fit the war-production machines you build with Veeder-Root Counting Devices that will help your customers to fight off the "bulls" . . . from miscounts and guesswork . . . that charge in and rip up production schedules where no up-to-the-minute operating records are available. With Veeder-Root facts in figures, they will be helped to avoid shortages and over-runs . . . to see maintenance needs well in advance of danger-points . . . to control high speed runs . . . and to improve interdepartmental co-ordination toward final assembly.

In sum, these truth-telling devices will help your customers to get, *consistently*, top performance out of your equipment. They are compact enough to fit readily into your designs . . . and can be supplied to count in any terms or units, mechanically or electrically. So if you are building war-production machines, fit them to make their work count to the utmost . . . with built-in Veeder-Root Devices.

VEEDER-ROOT Reset Stroke Counter with Totalizing Unit (the black-on-white figures at the left). A Medium Size Counter for speeds up to 1,000 counts per minute.

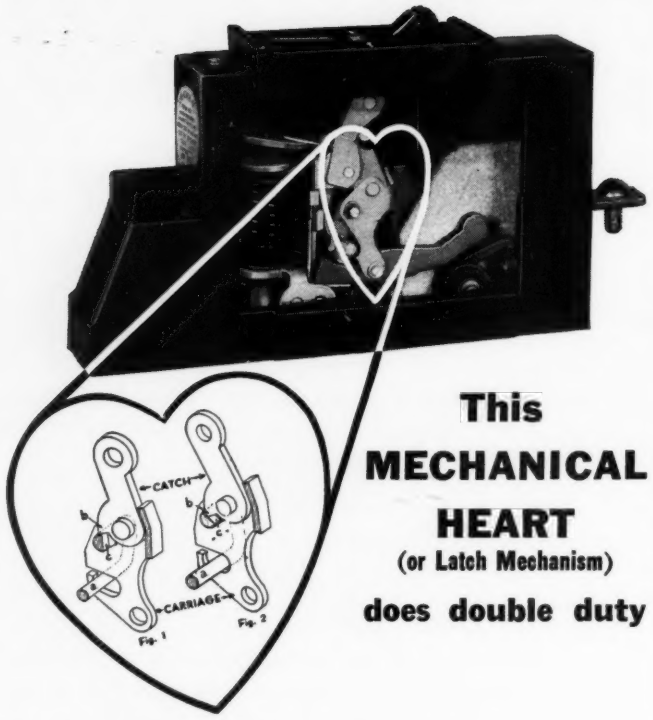


Veeder-Root Inc.

HARTFORD, CONN, U. S., A.

Offices in Principal Cities All Over the World

This HEINEMANN MAGNETIC CIRCUIT BREAKER bares its Mechanical Heart



This MECHANICAL HEART
(or Latch Mechanism)
does double duty

No. 1 It opens breaker with least mechanical delay

When the armature engages the lower leg of the lock (a) it rotates the lock enabling the tooth of the catch (b) to pass through the cut portion of the lock (c), thereby breaking the toggle and releasing the contacts which are under heavy spring pressure. *Of all known latches, this mechanism operates with the least amount of friction.*

No. 2 It opens breaker independent of handle operation

The relative position of the catch to the carriage remains the same as in Fig. 1 whether the handle is in the "on" position or turned to the "off" position, when the contact is broken manually. The latch collapses only under overload or short circuit conditions—*and it does that even if the handle is purposely held in the "on" position.* Fig. 2 shows the latch on its way to the collapsed position.

Send for Catalog 40 showing full line

HEINEMANN CIRCUIT BREAKER CO.
Subsidiary of Heinemann Electric
Est. 1888
113 PLUM STREET **TRENTON, N. J.**

Heil Co., Milwaukee, have been promoted to the position of works manager and chief inspector, respectively.

♦

HOMER H. WAGNER has been appointed chief electrical engineer of The Pennsylvania Transformer Co. He joined the company in 1932 as design and development engineer, later being promoted to electrical engineer. HARRY D. SALTON, who joined the company in 1936, was promoted to chief design engineer from his previous position as development and research engineer.

♦

K. L. HANSEN, consulting engineer, Harnischfeger Corp., has been appointed president of the American Welding society. He had served for two years as its vice president.

♦

EARL B. BUSENBERG, chief chemist of the Philadelphia Rubber Works Co. and well known throughout the rubber industry, has been loaned by his company to the government to serve on the staff of technical consultants.

♦

GERARD SWOPE, president of General Electric Co., New York, has been selected as the sixth recipient of the Hoover medal, which is administered by the Hoover Medal board composed of members of various societies and presented by the American Institute of Electrieal Engineers. Mr. Swope will be awarded the medal at the Institute's forthcoming winter convention. The recognition is given "to honor engineers for pre-eminent services".

♦

M. L. CARSON, acting engineer-in-charge, has been made manager of the engine and condenser department, Allis-Chalmers Mfg. Co. He was formerly engineer-in-charge of the engine and condenser department.

♦

ROY C. YANTIS has become connected with the development engineering staff of the Wolverine Tube division of Calumet & Hecla Consolidated Copper Co., Detroit, where he will serve as a mechanical engineer.

♦

CHARLES G. MAIER, noted metallurgist, has been added to the supervisory staff of Battelle Memorial institute, Columbus. Mr. Maier will direct and correlate an enlarged program of fundamental research and will serve as advisor and consultant to the institute's war research for the government and industry.

♦

GUY W. VAUGHAN, president of Curtiss-Wright Corp., was named president of the Aircraft War Production Council, East Coast Inc. GLENN L. MARTIN, president of Glenn L. Martin Co., is vice president. HARRY WOODHEAD, president of Consolidated Aircraft and chairman of the Vultee company, is president of the western organization, known as Aircraft War Production Council Inc.

♦

ALFRED R. GLANCY, chief of the New Automotive Combat Center of the Ordnance department at Detroit, and a one-time vice president of General Motors, has been advanced from colonel to brigadier-general.

GLOWELD PASSES RIGID TESTS WITH *High Honors*

Strength and Corrosion Resistance Established For *New* GLOBE Welded Stainless Steel Tubes...

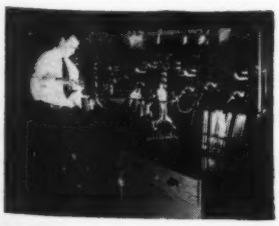
The ability of Gloweld Stainless Steel Tubes to pass exhaustive laboratory tests for corrosion resistance...tensile strength and bursting resistance . . . is important news to the chemical and process industries, food industries, pulp and paper, oil and other industries where these performance factors are vital.

These successful tests, coupled with Gloweld's comparatively lower cost, forecast wider applications for stainless steel tubing.

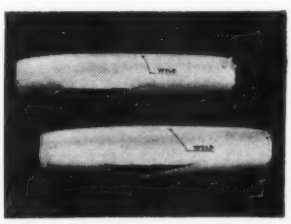
Gloweld is a development of Globe Steel Tubes Co., pioneer manufacturer of stainless steel tubing. It is produced by a closely controlled electric welding process resulting in very little "flash" at the weld, which is removed in a subsequent operation.

Gloweld is available in a wide range of diameters, and wall sizes, in practically all stainless steel analyses. Write for full information.

GLOBE STEEL TUBES CO.
Milwaukee, Wisconsin



Standard laboratory tests, with boiling 65% Nitric Acid, with Nitric and Sulphuric Acids, and by exposure to salt spray, and the Strauss Test, have established the corrosion resistance of Gloweld.



Gloweld Tubes were subjected to pressure until they burst. The weld in every case was as strong as the strip steel.

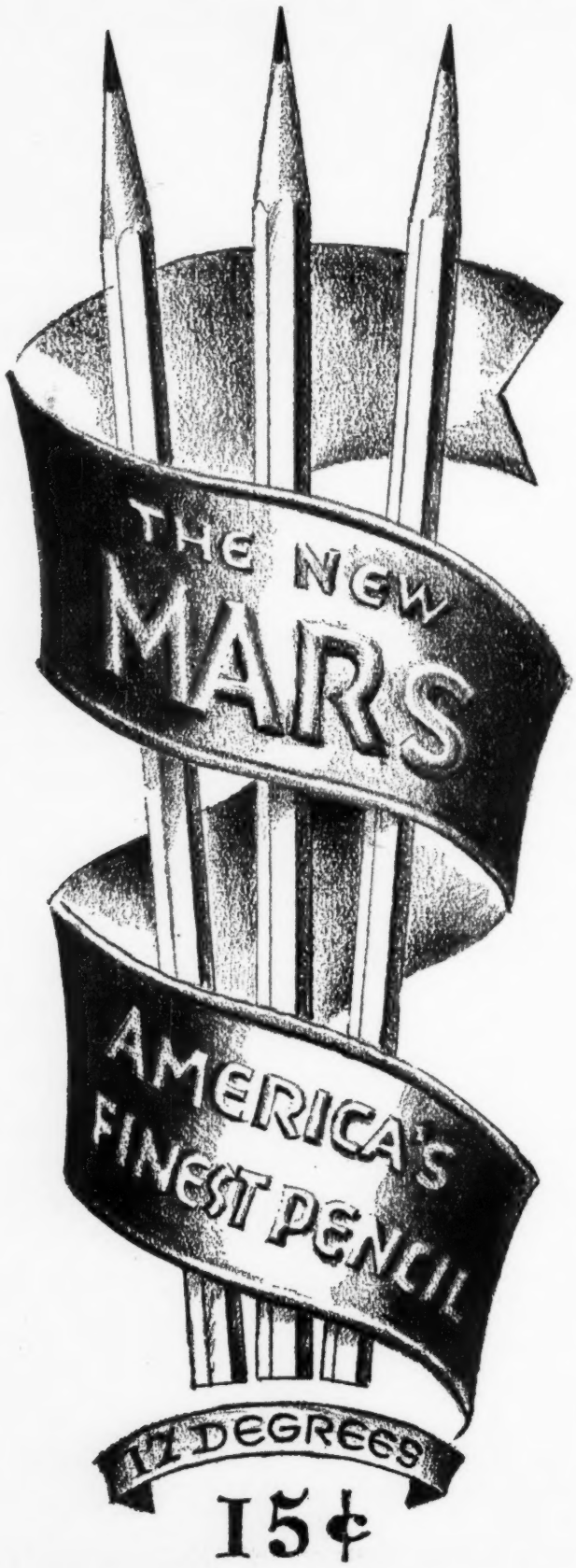
3001

★ STAINLESS TUBES
★ BOILER TUBES

GLOBE TUBES

★ CONDENSER AND HEAT EXCHANGER TUBES
★ MECHANICAL TUBING

GLOBE STEEL *Tubes*



J·S·STAEDTLER·INC·NEW YORK

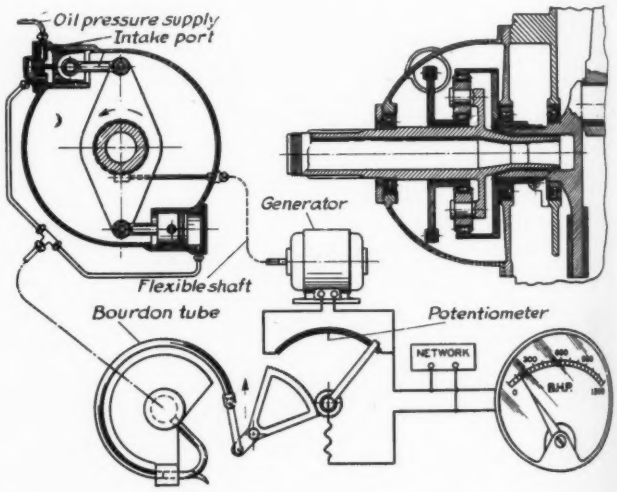
NATIONAL DISTRIBUTORS:
KEUFFEL & ESSER CO.
NEW YORK

NOTEWORTHY PATENTS

Indicates Power Output

INDICATION of the actual horsepower output of an engine at any time aids the operation of long range aircraft, where it is essential to maintain a predetermined power at which the engine operates most efficiently. An instrument for this purpose, covered by patent 2,297,644 assigned to Square D Co., is shown in the illustration.

Because horsepower is proportional to engine speed multiplied by torque, a speed-responsive and a torque-responsive device combine to give the required indication. The speed-responsive element is a single-phase



Generator output is proportional to engine speed and is modified by potentiometer controlled by torque, giving dial readings proportional to horsepower

alternating-current generator driven from the engine through helical gears and a flexible shaft. Its output is proportional to engine speed.

A torque meter incorporated in the planetary reduction gear of the engine provides the torque-responsive element. Torque reaction on the fixed sun gear is absorbed by a pair of hydraulic pistons working in cylinders supplied with oil under pressure. The intake port is controlled in response to movements of the pistons so that the cylinder pressure balances the torque at all times. This pressure, which is therefore directly proportional to the torque of the engine, actuates a bourdon tube, the movable end of which is linked to the mechanism of a potentiometer included in the circuit of the generator.

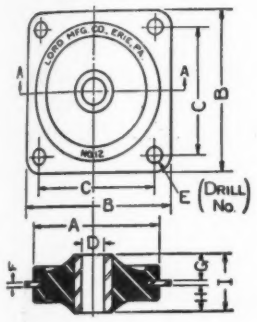
For a fixed position of the potentiometer, the indicating pointer moves in direct proportion to the engine speed. At a fixed engine speed, movement of the po-

Designing . . . FOR USE OF LORD MOUNTINGS

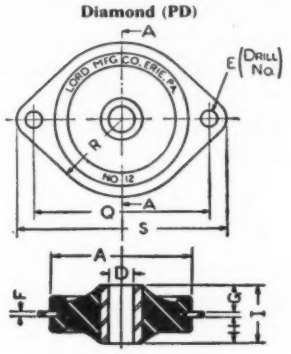
BONDED RUBBER

SPECIFICATIONS FOR LORD STANDARD PLATE FORM MOUNTINGS

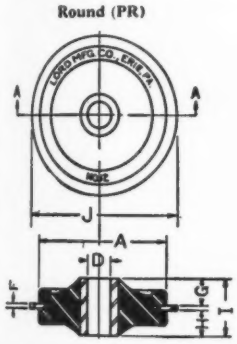
Square (P)



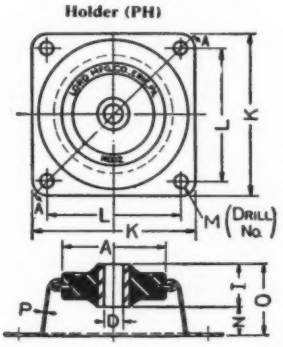
Diamond (PD)



Round (PR)



Holder (PH)



A study of the dimensional charts and illustrations will show that designing for use of Lord Plate Form Mountings in any equipment does not involve intricate layouts. Neither special tooling nor precision machining is necessary to accommodate them. Simply provide clearance for rubber body of mounting, bolts or screws for attaching plates, and bolt or stud for attaching the equipment to center sleeve. Lord Plate Form Mountings can be used in either a supporting or suspension position with equal effectiveness.

Lord Mountings are made in Plate Form and Tube Form, in snubbing and non-snubbing types and with load ratings ranging from a few ounces up to 1500 pounds. The principle of stressing rubber in shear when load is imposed, is used in all Lord Mountings.

Properly installed, all Lord Mountings definitely: Prolong equipment life by isolating vibration, which reduces metal fatigue, and prevents mechanical failure; increase production through elimination of close machining and precision alignment; save vital material by reducing equipment weight—inertia masses of machinery bases can be decreased in weight or eliminated; increase personnel efficiency by eliminating nerve wearing noise and vibration, translated through solid conduction; lower maintenance costs by protecting equipment against sudden load shocks and stresses, thereby minimizing repair and replacement operation.

For complete information covering all Lord Mountings, as well as an engineering discussion on vibration control, write for Bulletins 103 and 104, or call in a Lord Vibration Engineer for consultation on your design problems. There is no obligation.

Series	A	B	C	D	E	F	G	H	I
100	1"	1¼"	1"	.166"	.141"	.032"	.203"	.172"	13/32"
150	1½"	1¾"	1⅜"	.257"	.166"	.050"	.287"	.287"	5/8"
200	2"	2¼"	1¾"	.391"	.196"	.058"	.471"	.471"	1"
200X	2"	2¼"	1¾"	.391"	.196"	.058"	1.283"	.471"	1 13/16"

Series	J	K	L	M	N	O	P	Q	R	S
100	1 3/16"	1 11/16"	1⅜"	.141"	5/16"	23/32"	.025"	1.414"	⅝"	1.664"
150	1⅜"	2⅜"	1 15/16"	.196"	7/16"	1 1/16"	.032"	1.945"	⅞"	2.320"
200	2¼"	3"	2½"	.257"	½"	1½"	.037"	2.475"	1⅛"	2.975"
200X	2¼"	3"	2½"	.257"	½"	2 5/16"	.037"	2.475"	1⅛"	2.975"

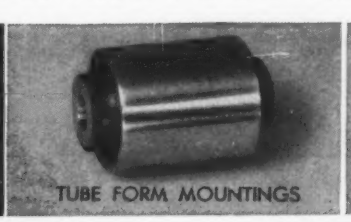
Series	Normal Load Rating 1/16" Deflection	Maximum Allowable Load
100	1 to 4 lbs.	1 to 4 lbs.
150	2 to 12 lbs.	3 to 18 lbs.
200	10 to 45 lbs.	20 to 90 lbs.
200X	60 to 90 lbs.	120 lbs.

These specifications on Lord Shear Type Bonded Rubber Mountings cover *Standard* Plate Form Types only. Cross sectional drawings show mountings under *rated load.* As shipped, dimension "G" is 1/16" larger and dimension "H" is consequently 1/16" smaller. On Holder Type, dimensions "N" and "O" will be 1/16" larger. Data on all other Lord Mountings is contained in our engineering bulletins. For special shapes, load ratings, materials or finishes, apply to factory

ORIGINATORS OF SHEAR TYPE BONDED RUBBER MOUNTINGS

LORD MANUFACTURING COMPANY . . . ERIE, PA.

LORD BONDED RUBBER SHEAR TYPE VIBRATION MOUNTINGS



REPRESENTATIVES . . . NEW YORK, 280 Madison Ave. . . . CHICAGO, 520 N. Michigan Ave. . . . BURBANK, CAL., 245 E. Olive Ave.

IT TAKES RUBBER IN SHEAR TO ABSORB VIBRATION

Inquiries are received almost daily from manufacturers asking if they can use ABSCO Meehanite in place of certain forgings or other cast materials containing critical alloys which are becoming more and more difficult to obtain. In many cases the answer is "YES!"

If you are faced with such a problem, regardless of what material you have been using, ABSCO Meehanite Castings may be the solution. Many manufacturers have found ABSCO Meehanite a permanent improvement over former materials used.

There are 21 types of ABSCO Meehanite Castings, providing an extensive range of physical properties which bridge the gap between steel and cast iron and meet a wide variety of other industrial service requirements.

Through our Selective Processing, a type of ABSCO Meehanite is available to meet these and other requirements:

1. **Strength, toughness and high damping capacity.**
2. **Ability to stand shock or strain.**
3. **Free machining qualities.**
4. **Density and solidity for pressure castings.**
5. **Heat and corrosion resistance.**
6. **Freedom from warpage that means constant alignment.**
7. **May be heat-treated for higher tensile strengths and increased resistance to wear.**

Regardless of what material you are now using, ABSCO Meehanite Castings may present qualities and advantages that will enable you to improve your product. You will be under no obligation by finding out! Write for hand book.

3180

THE AMERICAN BRAKE SHOE AND FOUNDRY COMPANY

BRAKE SHOE AND CASTINGS DIVISION

FOUNDRY
MAHWAH
NEW JERSEY

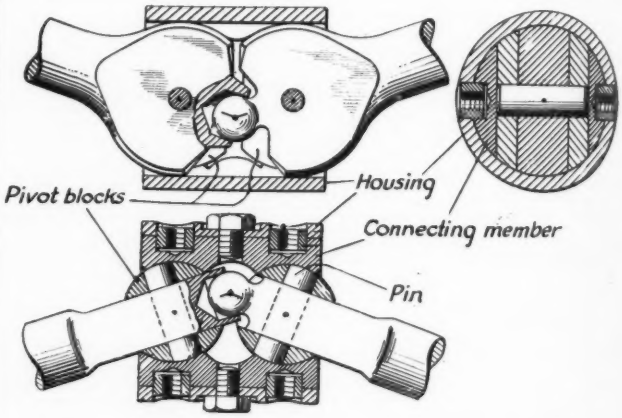
OFFICES
230 Park Avenue, New York, N. Y.
332 South Michigan Ave., Chicago, Ill.

tentiometer due to torque change modifies the generator output, giving pointer readings proportional to torque. The dial can therefore be calibrated in horsepower units, giving a direct reading. A network connected in the meter circuit counteracts changes in the meter indications due to frequency changes as the generator speed increases or decreases.

Universal Joint Is Compact

PERMITTING a considerable degree of angular displacement, the universal joint shown in the illustration also provides a relatively large effective surface for the transmission of torque. The design is covered by patent 2,297,457, vested in the alien property custodian.

Ends of the two shafts to be coupled are flattened parallel to the shaft axes, and are spherically curved along the longitudinal sides of the flat portion. Each shaft end fits into a two-part pivot block having a cylindrical cross



Large bearing surfaces contribute to effective though complicated universal joint

section. The pivot blocks fit into a central connecting member, the two cylindrical axes being parallel as shown in the lower illustration. Cylindrical outer surface of the connecting member fits into a housing, to which it is secured by bolts and dowels. The two shafts are guided at the intersection of their center lines by a spherical head on one which fits into a recess in the other.

As will be evident from the illustrations, angular deflection in one plane causes rotation of the shaft ends within the housing and in the other plane causes rotation of the pivot blocks within the connecting member. Because of its compactness and light weight, the joint is claimed to be particularly adaptable to automotive applications such as independent drives for sprung wheels.

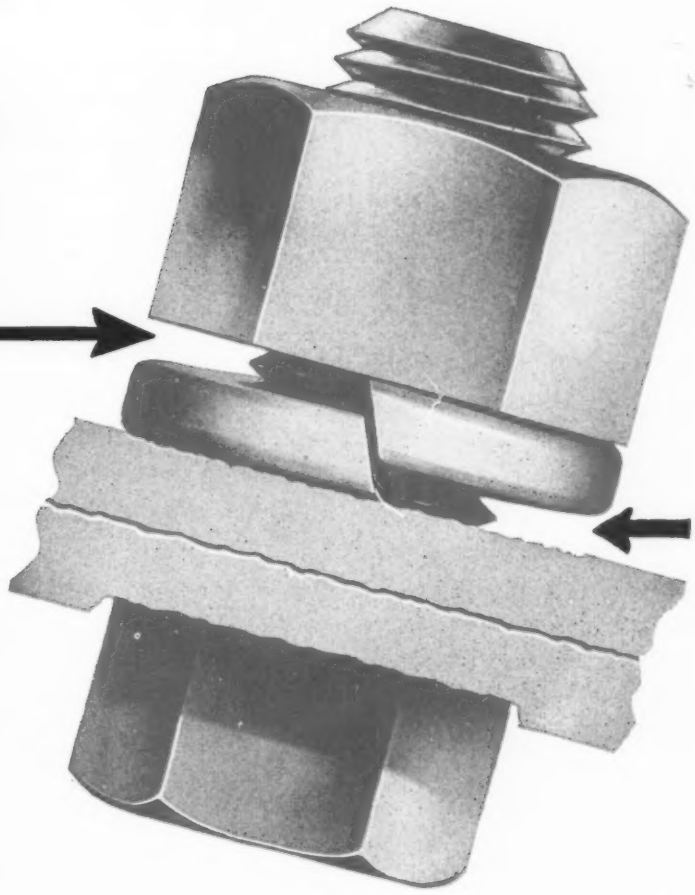
Provides Overload Release

WHERE it is desired to provide sudden release if a moving part strikes an obstruction, a patented design assigned to International Harvester Co. offers a solution of simple construction.

Designed primarily for use with agricultural implements, the device is shown in the illustration applied to a

A little spring can't go a long way

So when you order spring washers specify the ones with long range of spring power



INSIST ON KANTLINKS—the big long-range spring washers that expand and compensate for inevitable wear of bolted parts.... There is no substitute as economical on any assembly that is subjected to vibration. Short-range multi-toothed washers that bite in can not give you the wide expansion range of Kantlinks' **spring power.**

Furthermore, Kantlinks should be used with **every** type of nut, whether a regular standard nut or any one of the many fixed or locked nuts. For even if the nut never budges on the bolt, all other parts of almost every bolted assembly loosen sooner or later **unless** an adequate size helical **spring** washer is used to hold every part tight.

The parts will loosen because of bolt stretch, and frictional wear of metal on metal, burrs and flares, and because of pulverizing of paint, scale, and rust.

This is war time—be safer with powerful Kantlinks.

Let us send you samples—send details of your application. Test and compare them on the same job with **any** type of nut, or with any other type of washer. Kantlinks can't lose a real test. Try them for efficiency, economy and real safety.

Write today for descriptive folder.

THE NATIONAL LOCK WASHER COMPANY
NEWARK, N. J., U. S. A.

KANTLINK TRADE MARK

the long-range Spring Washer

THIS STANDARD PLUG DOES A SPECIAL JOB

It's hard to find a use or application for which a *standard* Cannon Connector is not suitable . . . because the Cannon Line comprises hundreds of sizes in a wide range of types and capacities.

A typical example is the use of a standard Cannon Plug as the connector for a new portable, power-driven saw. A special plug wasn't necessary. A *standard* plug, however, does a *special* job!

When you reach the point in your designs where you feel a *special* connector may be required, check with Cannon first. The chances are you'll find a *standard* Cannon Plug to do the job.

And . . . when you standardize on standard Cannon Plugs, you get assurance of long life and dependable performance under the most severe conditions.

CANNON SERVES MANY INDUSTRIES

Wherever electrical circuits must be connected or disconnected quickly, easily and where safety and dependability must be 100%, you'll find Cannon Plugs at work.

Tell us your problem and we'll gladly suggest the *standard* Cannon Plug which best meets your need.

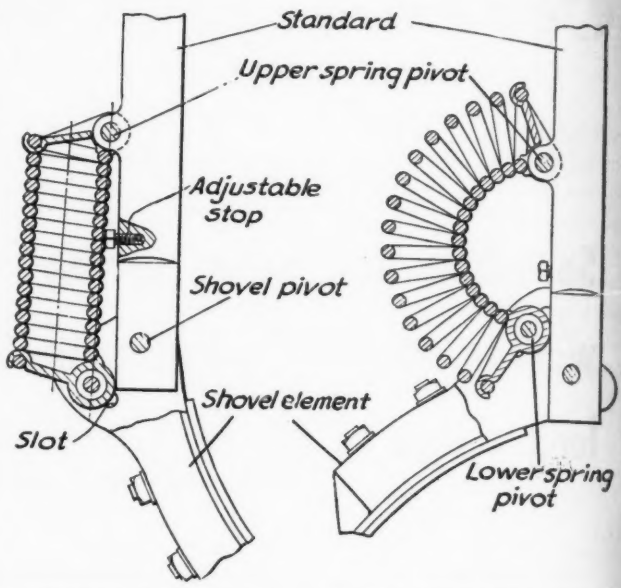
CANNON ELECTRIC

Cannon Electric Development Co., Los Angeles, Calif.

Canadian Factory and Engineering Office:
Cannon Electric Company, Limited, Toronto, Canada

Representatives in principal cities—consult your local telephone book

cultivator shovel. The shovel element which is pivoted to the standard is held in its normal position, as shown at left, by a spring of sufficient strength to resist the forces normally encountered in operation. Because the central axis of the spring is offset some distance from the pivot axis along which the resisting force acts, excessive force



Eccentrically loaded spring buckles when force exceeds predetermined value

tends to buckle the spring as shown in the right-hand view, permitting the shovel to clear the obstruction. Restoration to normal position occurs after passing the obstruction. The lower spring pivot fits into a slot in the shovel element, permitting the lower spring pivotal element to maintain contact with the standard as the shovel deflects.

Variation of the pressure necessary to trip the shovel is provided by an adjustable stop threaded into the standard. This stop is used to prevent the spring returning to its completely straightened position, thereby reducing the force necessary to cause buckling.

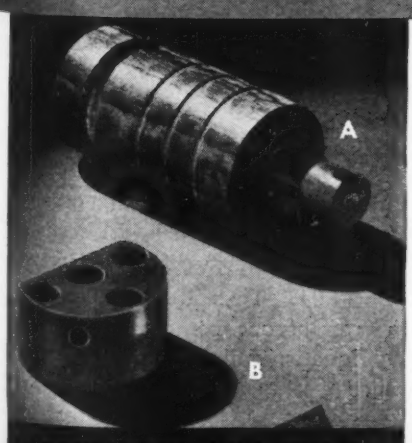
Enemy-Owned Patents Made Available

DRAWINGS and specifications of foreign-owned patent applications seized by the office of the Alien Property Custodian will be printed and made available to American industry at a nominal price. These applications ordinarily cover latest developments in patentable fields and many can improve American processes and devices.

Applications will be listed, as and when printed, in the *Official Gazette* of the United States patent office. Meanwhile, the Alien Property Custodian will make information contained in the files of these applications available, insofar as is practicable, to any person residing in the United States having a genuine legitimate interest therein.

Any registered patent attorney may obtain permission to inspect and make copies of the file of a vested application (other than an application which stands under secrecy order) upon filing a request. This action is necessary for pending applications because such applications are normally maintained in secrecy. The files of issued patents, on the other hand, are open to public inspection.

Night Patrol



A—Airbrake piston—drilled, turned and grooved on lathe, milled.
B—Insulator—bandsawed, turned, drilled, and counterbored.

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AMERICAN HEAVY-DUTY ROLLER BEARINGS

Rubber Compounds as Resilient Mountings

(*Continued from Page* 65)

of unit of machinery supported by resilient mountings (slugs). Equation 9 may be written

$$\omega_n^2 = \gamma k_{st}/m \quad \ldots\ldots (10)$$

where k_{st} = static spring constant of resilient mounting, determined from slope of static load-deflection curve, and γ = ratio of dynamic to static stiffness. Substituting Equation 10 in Equation 8

$$P_1 = (1.26C/m)\gamma k_{st} \quad \ldots\ldots (11)$$

where C and m are constants for any given unit of machinery.

Thus, it is evident that the properties of the rubber compound which influence the effectiveness of the mounting in reducing the force transmitted to the foundation structure, at the normal operating speed of the unit, are γ and k_{st}.

For the second consideration, Equation 4 becomes

$$P_{1max} = C\omega_n^2 \epsilon_{max} \quad \ldots\ldots (12)$$

Substituting as in Equation 11

$$P_{1max} = (C/m)\gamma k_{st}\epsilon_{max} \quad \ldots\ldots (13)$$

It is seen that the maximum periodic force transmitted to the foundation structure at resonant frequencies is influenced by γ, k_{st}, and ϵ_{max}.

In the third consideration, the exact relationship, Equation 5, is modified by multiplying the right-hand member by

$$\sqrt{1+\left(2\frac{c}{c_c}\frac{\omega}{\omega_n}\right)^2}$$

This results in the following approximate equation (see Equation 1)

$$x_{0max} = (P_0/k_{dy})\epsilon_{max} \quad \ldots\ldots (14)$$

The maximum error introduced by this modification occurs with $c/c_c = .071$. Since ω/ω_n is unity when ϵ_{max} occurs, the maximum value of the foregoing modifying factor is $\sqrt{1 + (2 \times .071)^2} = 1.01$. Thus, this modification introduces a maximum error of one per cent, which is negligible. Substituting Equation 2 in Equation 14, and recalling that at resonance

(*Continued on Page* 132)

TIGHTSPOT BREAKERS

TIGHTSPOT BREAKER
Anthony Dapuzzo
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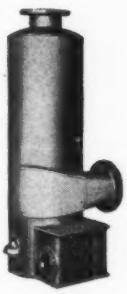

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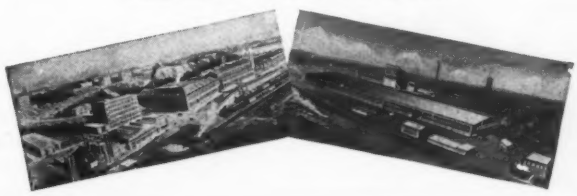

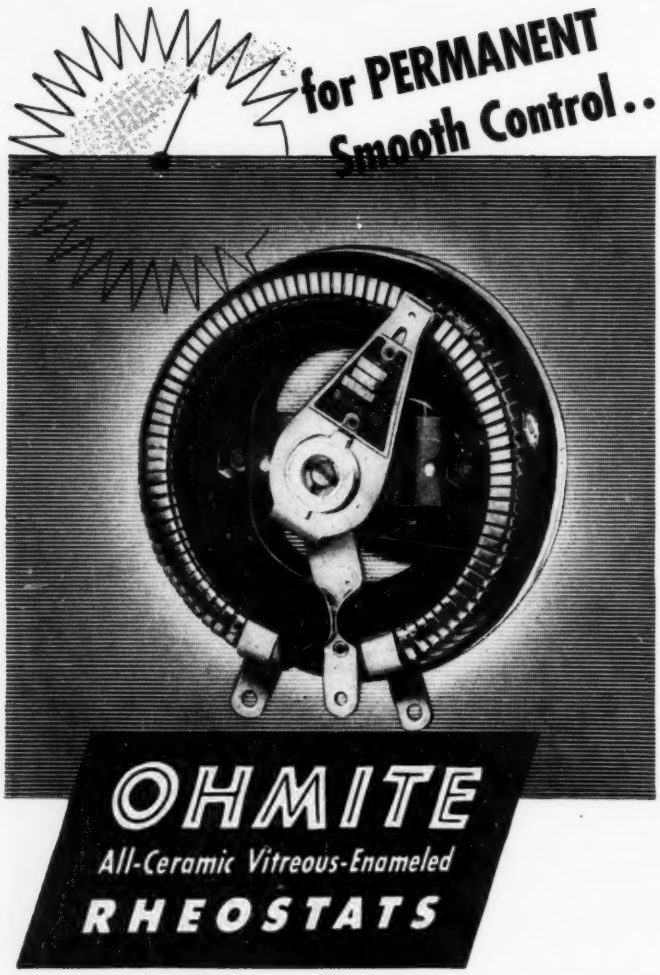

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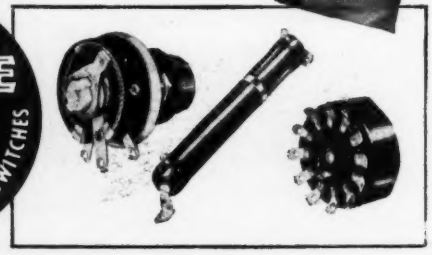

(*Continued from Page* 126)

$$x_{0max} \approx (C\omega_n^2 / k_{dy})\epsilon_{max} \quad \ldots\ldots (15)$$

Substituting Equation 9 in Equation 15

$$x_{0max} \approx (C/m)\epsilon_{max} \quad \ldots\ldots (16)$$

From Equation 16, it is apparent that the only property of the rubber compound influencing the maximum amplitude of vibration of the unit of the machinery is ϵ_{max}.

In the fourth, and final, consideration an approximate relationship, deduced from Equation 15, is as follows

$$x_0 \approx (C\omega^2 / k_{dy})\epsilon \quad \ldots\ldots (17)$$

Substituting Equation 6 in Equation 17

$$x_0 \approx C\omega_n^2 / k_{dy} \quad \ldots\ldots (18)$$

Substituting Equation 9 in Equation 18

$$x_0 \approx C/m \quad \ldots\ldots (19)$$

To check the validity of Equation 19, values of x_0 were determined from Equation 5, which is exact. An approximate value of x_0 within 6 per cent of the exact value, at any part of the band designated "normal operating speed" in *Fig.* 2, is given by

$$x_0 \approx 1.07C/m \quad \ldots\ldots (20)$$

Thus, the amplitude of vibration of the unit of machinery at its normal operating speed is seen to be substantially independent of the properties of the rubber compound.

To summarize, the effectiveness of the shear-stressed rubber compounds in the typical mounting is indicated by Equations 11, 13 and 16.

Factors Governing Selection

In the ideal resilient mounting P_1, $P_{1\,max}$, and $x_{0\,max}$ should each have the lowest possible value, that is, the values of γ, ϵ_{max}, and k_{st} should each be a minimum. The ratios γ and ϵ_{max} are measurable only when the rubber compound is subjected to an oscillating load, while k_{st} is measurable when the compound is loaded statically. In general, the selection of a rubber compound and the design of the mounting should be based upon as low a value of k_{st} as is compatible with the allowable static deflection, drift, and strength requirements. Determination of drift depends upon measurements over a long period of time and is beyond the scope of the present investigation. Good design of a resilient mounting would dictate that the working load imposed upon the rubber compound should not exceed its endurance limit. Since the determination of the endurance limit of each compound is also beyond the scope of this investigation, the breaking strengths of the mountings, under gradually applied loads, are used as an indication of the relative endurance limits of

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the rubber compounds investigated.

This leads to the suggestion of a criterion β', for the determination of the relative effectiveness of different rubber compounds used in the typical mounting

$$\beta' = \frac{\gamma \epsilon_{max} k_{st}}{Q} \quad \ldots\ldots (21)$$

where Q = breaking strength of resilient mounting (pounds). In general, the compound exhibiting the lowest value of β' would be the most effective.

Since this criterion was derived for a mounting of specific dimensions, it is desirable to define the component factors in a more general manner. As previously defined, γ and ϵ_{max} are dimensionless ratios.

Defining G as the applied load W (pounds) per unit of shear-stressed rubber area A (square inches) necessary to produce unit deflection of the mounting Δ (inches) per unit thickness of the rubber stressed in shear t (inches),

$$G = \frac{W/A}{\Delta/t} = \frac{Wt}{\Delta A} \text{ pounds per square inch} \quad \ldots\ldots (22)$$

When G is thus defined, it represents the shear modulus of elasticity of the rubber compound. In the typical mounting, t = .5-inch, A = 2 square inches, and $W/\Delta = k_{st}/12$ pounds per inch. Then, if k_{st} is in pounds per foot

$$G = k_{st}/48 \text{ pounds per square inch} \quad \ldots\ldots (23)$$

Defining S as the breaking strength Q (pounds) per unit of shear-stressed area A (square inches) of the rubber compound,

$$S = Q/A = Q/2 \text{ pounds per square inch} \quad \ldots\ldots (24)$$

in the typical mounting. Substituting Equations 23 and 24 in Equation 21

$$\beta' = \frac{24 \gamma \epsilon_{max} G}{S} \quad \ldots\ldots (25)$$

Since G and S have like dimensions, β' is dimensionless.

For comparing the effectiveness of rubber compounds, $\beta = \beta'/24$ may be used instead of β'. Therefore, in a generalized dimensionless form, the suggested criterion is

$$\beta = \frac{\gamma \epsilon_{max} G}{S} \quad \ldots\ldots (26)$$

Thus, in general, the most effective rubber compound for use in a shear-stressed resilient mounting is the one with the lowest value of β.

A summary of the data and results of calculations leading to the evaluation of β for each of the compounds tested is presented in TABLE III. It is apparent from column 10 of this table that β is nearly a constant for each compound, regardless of applied load. Therefore, it is allowable to use the average, as given in column 11, as the representa-

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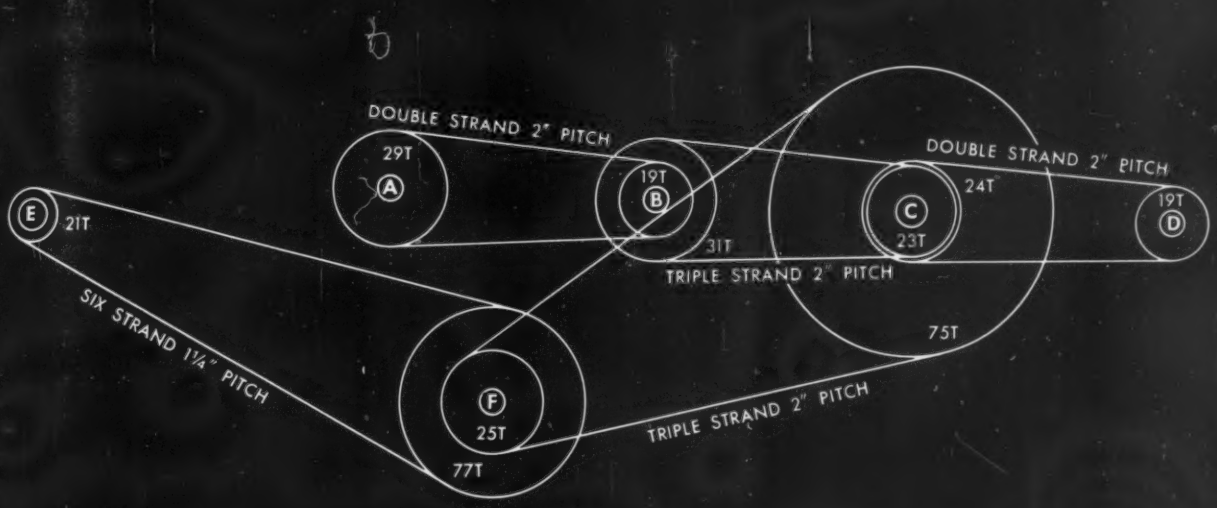

LAYOUT OF DRIVES—150 HORSE POWER—WIRE DRAWING MACHINE

A—FIRST CAPSTAN SHAFT—27 R. P. M. C—THIRD CAPSTAN SHAFT—55 R. P. M. E—MOTOR SHAFT—600 R. P. M.
B—SECOND CAPSTAN SHAFT—41 R. P. M. D—FOURTH CAPSTAN SHAFT—69 R. P. M. F—COUNTER SHAFT—164 R. P. M.

Original Drives Were Replaced by DIAMOND Roller Chain Drives·

● War needs demanded immediate increase in the production of copper wire in the plant of an eastern wire company. With minimum new equipment, larger motors, and improved drives for continuous operation, the problem was solved and the greater output secured.

The illustration shows the new drives on one machine which reduces square copper rod billets to hardened copper wire at the rate of 60 miles a day. The original 100 h. p. motor was replaced by one of 150 h. p., and the original drives were replaced by Diamond Roller Chain Drives.

These drives transfer this greater horsepower, withstand motor starting torques of 300% overload, and have operated continuously every day and all day since the installation was made early this year.

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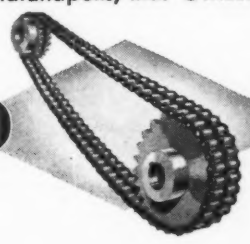
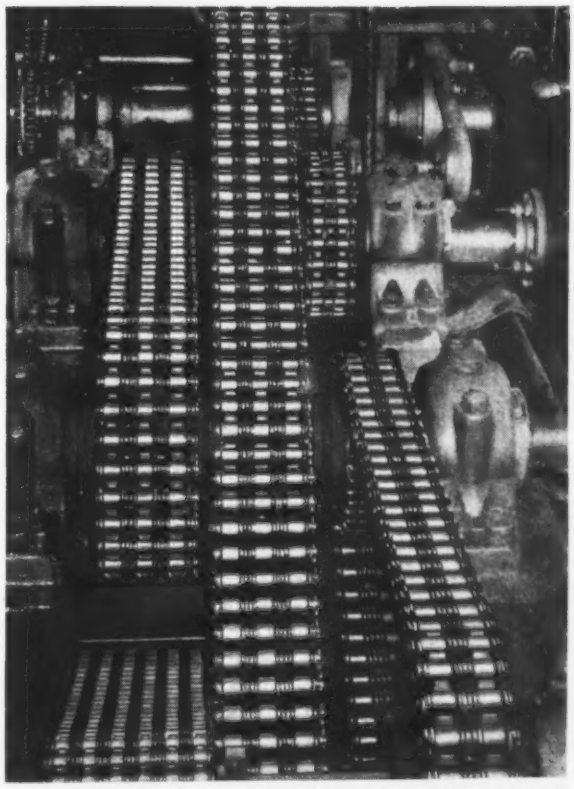


DIAMOND ROLLER CHAINS



View showing the wire mill Diamond Roller Chain drives indicated in the drawing above,—with only a portion of the six-strand drive showing in the foreground.

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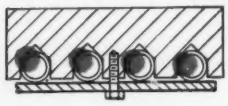
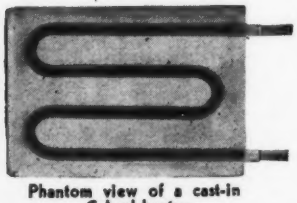
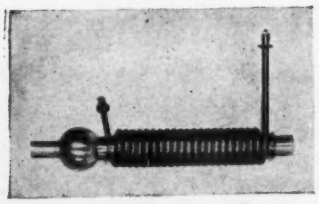
Calrod heaters suspended over tank side for heating liquid inside



Calrod heaters placed in grooves



Phantom view of a cast-in Calrod heater



Calrod heater wrapped around refrigerator machine nozzle

They are made in ratings and finishes for practically every job where metal surfaces, soft metals, or liquids need to be heated. Sealed terminals are supplied where any liquids are encountered.

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GENERAL ELECTRIC

tive value of β for each compound.

Neglecting the high value of β obtained for compound *A*, which was obviously due to poor strength, it is seen that for compounds which have a satisfactory strength and shear modulus of elasticity, the value of β varies approximately from 2.5 to 7. With this variation in the value of β, it was justifiable to neglect errors occasioned by using approximations in its development.

It is believed that the suggested criterion is useful as a general measurement of the effectiveness of rubber and

TABLE III

Summary of Results

Compound	Load, lb	f_n cycles per sec	k_{dy} lb per in.	k_{st} lb per in.	γ **	G psi	ϵ_{max} * **	S psi	β **	β* **
A	27.65	10.5	312	287	1.09	71.8	20.0	90	17.4	17.2
	47.65	8.0	312	277	1.13	69.3	....	...	17.4	....
	67.65	6.6	302	273	1.11	68.3	....	...	16.8	....
B	47.65	9.5	440	387	1.14	96.8	19.6	410	5.28	5.19
	67.65	7.8	421	362	1.16	90.5	....	...	5.02	....
	87.65	7.0	439	355	1.24	88.8	....	...	5.26	....
D	27.65	14.5	593	555	1.07	139	22.2	465	7.11	6.98
	47.65	11.0	589	514	1.15	129	....	...	7.09	....
	67.65	9.1	572	490	1.17	123	....	...	6.89	....
	87.65	7.95	567	490	1.16	123	....	...	6.82	....
F	27.65	14.9	627	422	1.49	106	11.1	390	4.48	4.30
	47.65	11.0	589	362	1.63	90.5	....	...	4.18	....
	67.65	9.3	598	353	1.69	88.3	....	...	4.23	....
G	27.65	15.1	644	369	1.75	92.3	9.4	413	3.68	3.43
	47.65	10.9	578	340	1.70	85.0	....	...	3.29	....
	67.65	9.2	585	318	1.84	79.5	....	...	3.33	....
J	47.65	6.8	225	187	1.20	46.8	17.0	380	2.51	2.51
K	47.65	17.1	1430	698	2.05	175	7.05	503	5.03	5.09
	87.65	12.8	1470	445	3.30	111	....	...	5.14	....

*Average value.
**Dimensionless ratio.

Testing temperature 75 F ± 3 deg.
$f_n = \omega_n/2\pi$.

rubberlike compounds employed in resilient machinery mountings. However, the characteristics of the machine and the type of service involved may affect the choice of magnitudes of certain factors comprising the criterion. Thus, two rubber compounds may have nearly the same value of β and nearly the same value of the ratio G/S; the first compound may exhibit a relatively large value of γ and a low value of ϵ_{max}, while the second compound exhibits a relatively small value of γ and a large value of ϵ_{max}, the product, $\gamma\epsilon_{max}$, being approximately the same in both cases. If the machine which is to be mounted on rubber supports is one which operates at full speed during most of its running time and passes quickly through the resonant frequency as it is started and stopped, the second compound, with the lower value of γ, would be more satisfactory, since from Equation 11, γ influences the force transmitted to the foundation structure at the normal operating speed. Since the resonant speed would occur only briefly, sufficient time would not be allowed for large amplitudes of vibration to build up, and the larger value of ϵ_{max} would not be detrimental (see Equations 13 and 16). On the other hand, if the machine is one which operates at, or near, the resonant frequency for extended periods of time, or if it passes slowly through this frequency as it is started or stopped, the first compound, with the lower value of ϵ_{max}, would be more satisfactory.

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Aircraft Engine Bearings

(*Continued from Page* 73)

Further increases in power (again without change in bearing size) brought forth a revival of an old (1912) Gurney bearing type with split inner race, comprising two angular contact type bearings in a single row (*Fig* 2); what appears to be a four-point bearing is really two two-point bearings, thus permitting a nearly full complement of balls, and a steeper angle of contact, with two or three times the thrust capacity. The bearing is designed to separate completely for thorough overhaul inspection.

The propeller bearing must carry a large momentary radial load due to gyroscopic forces when the airplane goes through violent gyrations. Coming out of a dive does not represent the peak, other conditions in the airplane limit the dive loads to about ten times gravity. Far worse loads occur in a tight radial spin taken at two radians per second for bombers and a possible three radians per second for highly maneuverable pursuit ships. Theoretical moments of 200,000 inch-pounds produce forces taxing the bearings, especially when the two front bearings are relatively close together.

On all but the largest engines, the front ball bearing carries this large momentary radial load as well as the thrust load. The largest engines frequently introduce a separate roller bearing for radial support, but recent tests indicate that the new split inner race thrust bearing may make the roller unnecessary.

Rocker Arm Bearings Present Problems

For current large engine rocker arm bearings, a one-piece double-row ball bearing is used, with the maximum possible number and size of balls and no cage or separator. Tapered roller bearings of roughly similar design also are used. Very fine race finish and unusually accurate bearings help ward off "false brinelling" [3], a race pocketing condition that results from the very short movements, (about 1/32-inch on the race path).

Antifriction bearings of this back-to-back construction are common on radial engine rockers because the push rods angle considerably and produce severe sideways tilting effects, which this bearing type resists. The smaller radial engines still retain two single-row ball bearings opposed, thus obtaining a similar effect with standard parts.

Besides relatively high loads, the rocker arm location also involves high temperatures, high enough definitely to soften the common ball and roller bearing steels. Checks by the softening indicate 450 degrees Fahr. frequently, and higher in rare cases. Fortunately these occur only during periods of maximum engine output and do not last long. The indicated research is for steels that will maintain high hardness at these temperatures. Noteworthy is the fact that inner races suffer more than outer races. The heat evidently travels along the cylinder walls and slight improvements might be obtained by reduced heat paths and localized greater cooling, where the strength requirements for rocker box support permit.

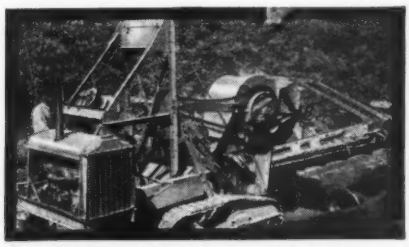
The same heat problem accounts for the relatively poor performance of the early grease-lubricated rocker bearings on high output radial engines. The temperature un-

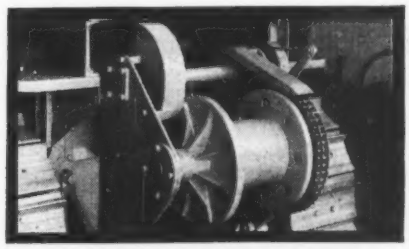
"SURE IT'S A BIG CATALOG, BUT IT TELLS ONLY PART OF THE STORY!"

1 THERE'S MUCH MORE to the Chain Belt story than we can cover in the 768 pages of this No. 444 catalog. In it we can show and describe the *standard* types and sizes of chain belt but we can't show the countless special chain belts and adaptations which our engineers are constantly designing.

2 WHAT OUR SPECIAL SERVICE DOES— Frequently the drive problem or extraordinary physical characteristics of a new machine are such that no standard type of chain belt will meet every condition. When this occurs, our engineers either design new chain belt or adapt standard types as required.

3 CORROSION WAS THE PROBLEM— Here was a case where corrosive influences were so great that Chain Belt engineers recommended a special chain belt of Z-Metal. Standard chain belt might have been satisfactory for a time but the special application was sure to give far longer and more efficient service.





4 IT CALLED FOR SUPER STRENGTH— To draw the tubes to be used in shock absorbers for bombing planes, a chain with a 200,000-ton pull and an ultimate strength of 1,500,000 pounds was needed. That kind of chain belt isn't kept in stock so chain belt engineers designed one especially for this job.

5 INCREDIBLE SPEED DEMANDED— The pace of this drive under continuous operation was far beyond ordinary practice. Since standard chain belts for power transmission are built for high speed, the installation was handled by making certain adaptations to conform to the excess which was called for.

6 EXTREMELY COMPLEX DESIGN— In this instance, the drive of the machine was exceedingly complex and the space limitations were an important factor. Chain Belt engineers collaborated with the designer to work out a special chain belt installation, meeting every requirement of design and service.

If you haven't a copy of the 768-page Chain Belt catalog, the Rex man will gladly bring you one—and he is at your service if you are confronted with a problem having to do with the transmission of power or timing operation that any of the more than 2000 sizes and types of Rex chain belt can help you solve. Write or call Chain Belt Company, 1643 W. Bruce St., Milwaukee, Wis.

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★ INDICATION
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Stow Flexible Shafting has proved itself invaluable in modern machine design. When remote control is necessary, but cost and lack of space eliminate gearing . . . when indication is complicated by vibration, heat or similar factors . . . when power must be transmitted off center or at an angle. . . . Stow flexible shafting provides a simple, highly efficient solution.

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Let us—as the inventors of the flexible shaft—put our 66 years of experience to work on your specific problems. In writing, please include the following data:

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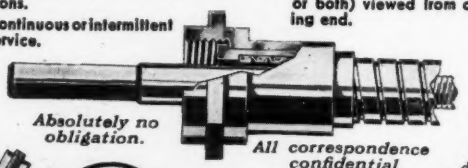
2—H. P. and speed, or torque.
3—Severe running or starting conditions.
4—Continuous or intermittent service.
5—Unusual external operating conditions.
6—Rotation (either direction, or both) viewed from driving end.



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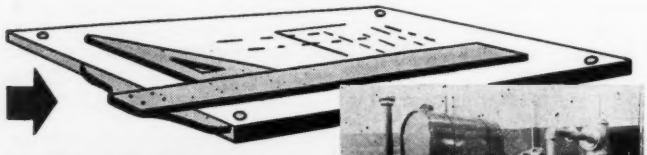
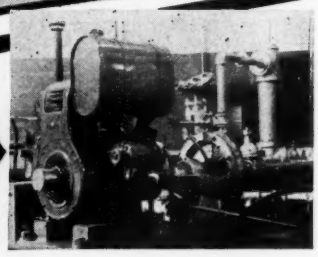


ON THE BOARD
OR ON THE JOB



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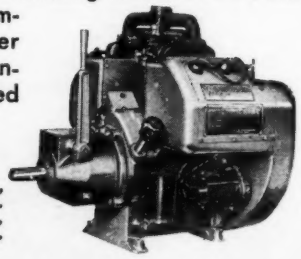
In the development of new equipment, as well as in the efficient utilization of existing machines . . . the power factor is more important today than ever before. That's why Wisconsin Heavy-Duty Air-Cooled Engines rate Number One Consideration.



Model VE-4, 22 hp., 4 cyl., V-type Engine. Other types and sizes, 1 and 4 cyl., 1 to 35 hp.

MOST POWER Per POUND

WISCONSIN MOTOR
Corporation
MILWAUKEE, WISCONSIN, U. S. A.
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doubtedly baked the grease out rapidly, leaving the bearings unprotected and adding a hard carbon residue that fostered "false brinelling". High output engines have now been converted to oil lubrication for rocker arms, giving:

1. Maintained lubrication
2. Covering of surfaces to help keep the air away and reducing the "fretting corrosion action of false brinelling
3. Better heat transfer to the cooling surfaces.

Oil lubrication has not been found necessary on some of the smaller engines with lower head temperatures. On in-line engines where push rods are perpendicular to the rocker axis, no side tilt occurs and ball bearings have not been found necessary; bushings prevail with occasional use of needles for their lesser oil demands. Bushings are also on test for the radial engine.

Precision Bearings Meet Supercharger Requirements

Extreme speeds and large power concentrations have been successfully met with the same super precision ball bearings originally developed for high speed grinder spindles. A typical mounting (*Fig.* 3) delivers about 100 horsepower maximum at 36,000 revolutions per minute on a ¾-inch shaft. A counterbore or one shallow-shoulder type bearing is commonly used for its greater number of balls. The one-piece retainer is made for this service out of tightly laminated bakelite tubing with cotton base. One of the three bearings carries only the thrust load resulting from the air pressure on the back side of the rotor, occasional reverse loads being taken by one of the radial supports. This isolation of radial and thrust loads yields more capacity per space and allows higher top speeds.

One very difficult problem is sealing against blower pressure alternating with high suction when throttled. Oil leakage at this point may dangerously foul the valve system. In similar designs for cabin superchargers, the seals must be so tight as to prevent a leakage of even a "smell" of oil. The most common method provides two seals with a very liberal drain to the atmosphere between them to carry off any engine oil leakage and to permit only air leaking into the blower system.

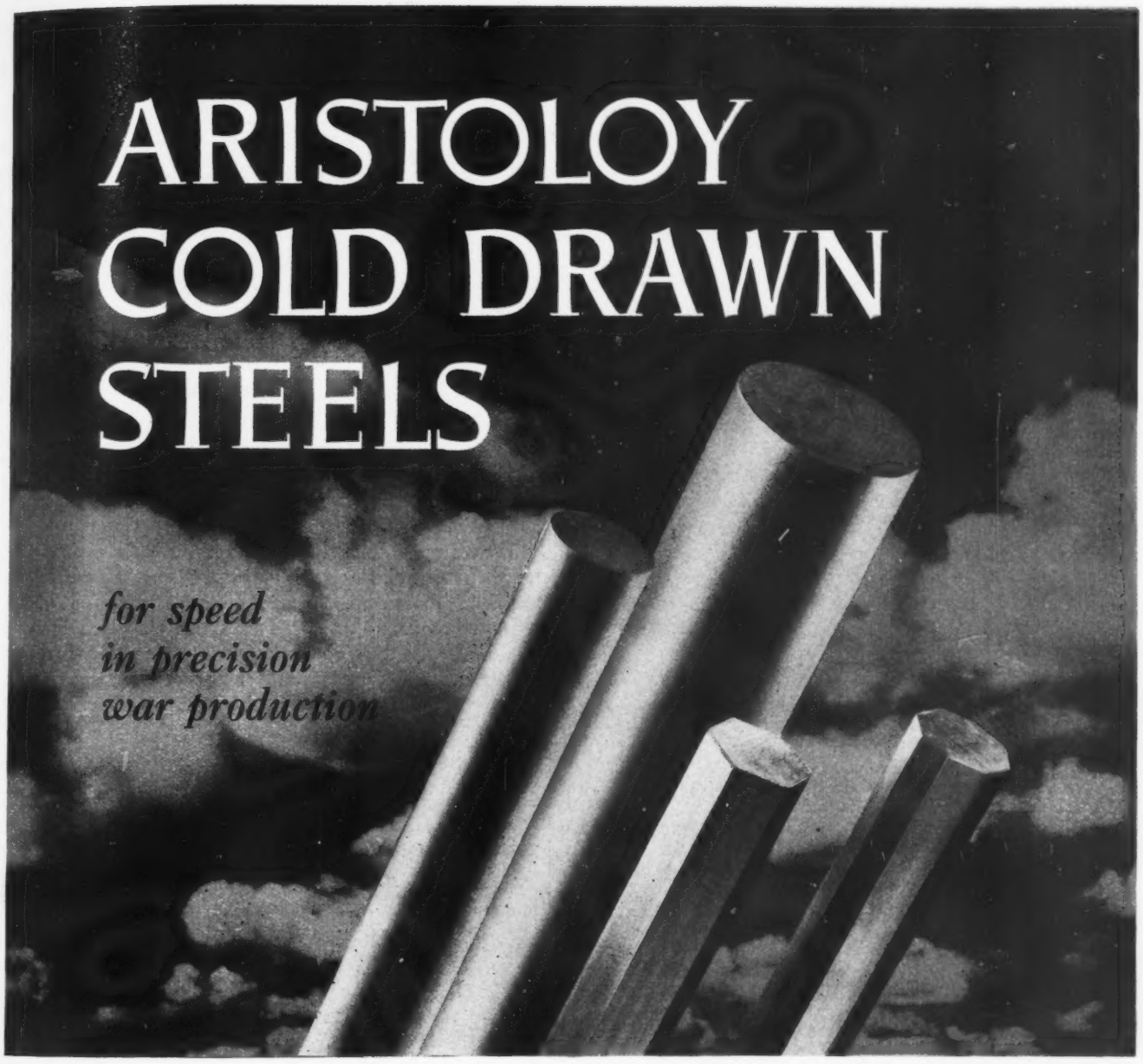
The design of *Fig.* 3 was at first frequently used with two cylindrical roller bearings and one "conrad" ball bearing for thrust only, but in the U. S. was superseded by the three interchangeable radial type ball bearings shown. However, it is now questionable whether the change in bearing type contributed so much to the great increase in reliability as did the increased accuracy and certain radical changes in mounting principles as follows:

a. Liberal oiling instead of the scant lubrication previously thought necessary for top speeds. However, the lubricant is not passed through the bearing but is permitted to wash off the sides. serving mainly for heat dissipation and temperature equalization. In one test on an engine with thermocouples on the bearing outer race, the temperature started at 295 degrees Fahr. with very slight oil feed gradually dropped to 225 degrees Fahr. as the oiling increased, and then started to rise again slowly. These temperatures may seem high, but the entering oil starts at 170 to 190 degrees Fahr.

b. Relatively loose bearings and looser fits in the housings. An extensive German test[4] indicated that the internal looseness served mainly for oil films that otherwise developed excessive heating at high speeds. Allowances must also be made

ARISTOLOY COLD DRAWN STEELS

for speed in precision war production



Cold Drawn Steels have the vital wartime job of keeping fast automatic production machines operating continuously at peak loads. The uniform surface and close tolerance of Aristoloy Cold Drawn Steels assure smooth machining with longer tool life and uninterrupted production.

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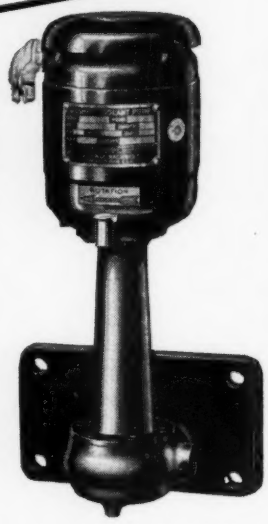
Designed and built by the originators of the Vertical Packless Motor pump, the Gusher line today is "known" for dependable, carefree operation.

Gusher Pumps are favorites among leading machine tool makers and users. There's a Gusher to your fit needs. Write!



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for appreciable temperature differentials, especially when an aluminum housing may be considerably chilled by a large volume of cold stratosphere air. In one extreme case, the outer race needed .0025 radial looseness in the housing.

c. Present bearing capacity tables are practically ignored. Apparently the lower loads that go with extreme speeds are all within the fatigue limit. The major problem is removing the heat generated within a small volume of metal. Even with very low coefficients, there is an appreciable friction energy to be dissipated because of extreme speeds and high power. Based on present ratings, factors down to .35 (load/rating) are in use here and .20 on one foreign military engine.

Astonishing reliability has been achieved, using these factors, at high speeds; as low as one or two field failures in ten thousand sets. Of course, this is based on conservative airline practice of replacing supercharger bearings at every major overhaul (500 to 600 hours) even though rarely indicated by the condition of the bearings.

Antifriction bearings prove highly desirable for the overhung rotors because the bearings are so close together, and small radial and axial clearances must be maintained between the blower and casing. Some superchargers "straddle" mount the blower between bearings and bushings become more practical, but they involve high oil flow and careful design especially for thrust load. One European design employs a bushing at one end and a ball bearing for thrust and radial loads at the other.

Controllable Propeller Blade Bearings

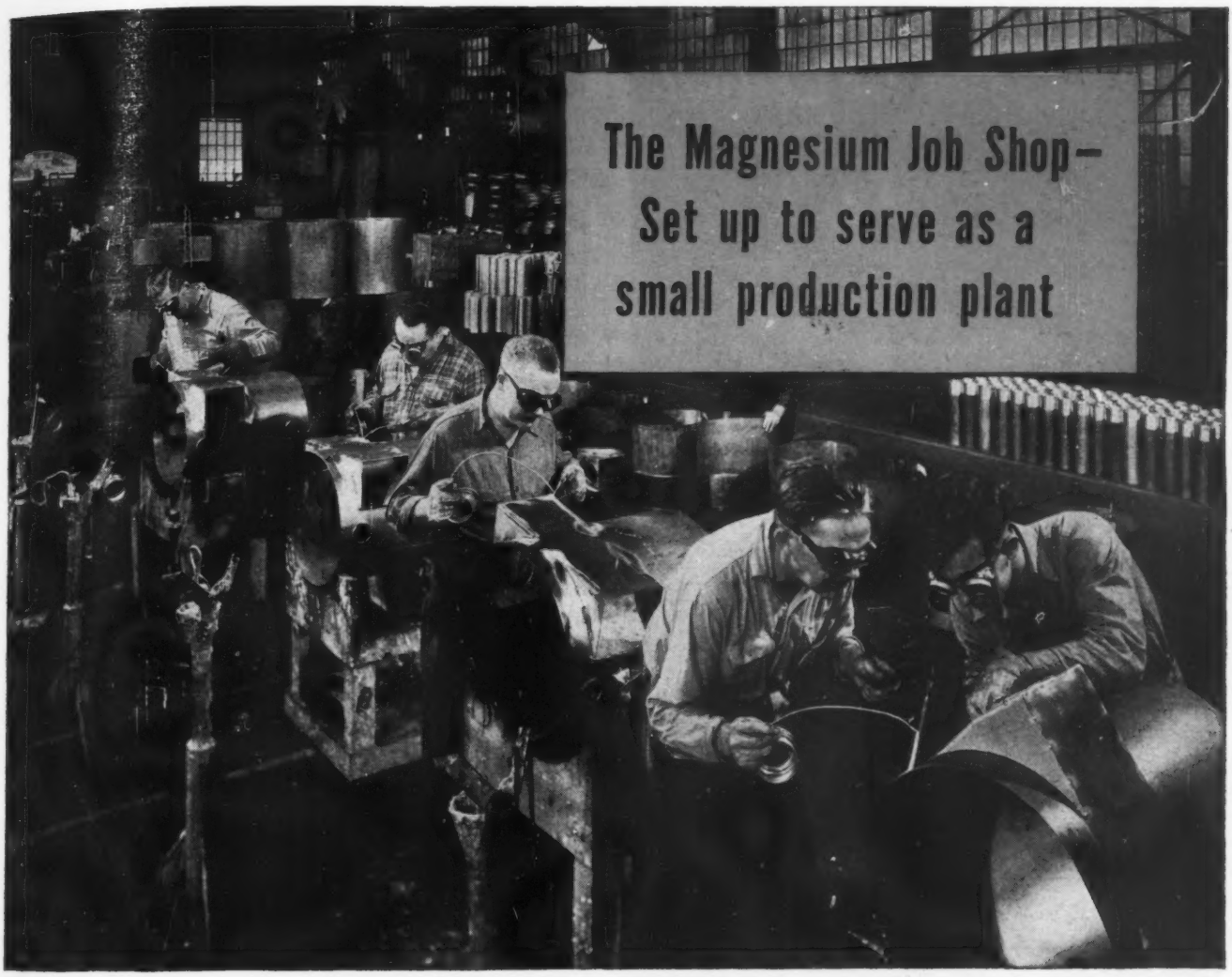
The blades of a controllable propeller require rigid support and fairly free rotation for blade angle changes. The bearings must be designed for

1. Extremely large centrifugal forces (200,000 pounds maximum)
2. Aerodynamic forces at large overhangs
3. Severe tendency to vibrate and "false brinell".

The late German and English designs use mostly tapered roller bearings or ball thrust bearings.

One of the most popular makes of American controllable propellers uses a flat plate thrust bearing with short cylindrical rollers of square section and two separate bushings inside the blade for overhung air forces. Most of the other U. S. designs and one English propeller employ what is now called "stacked bearings", (*Fig.* 4), a series of angular contact type ball bearings, ground to divide load[5]. Several rows of small balls dividing the load provide larger thrust capacities per pound weight and for the space than can be obtained with one row of large balls. The usual "stack" weighs about 6 pounds for 250,000 pound thrust brinell capacity, a much higher intensity of loading than has ever been used before.

To obtain such high capacities the race curvatures are made to extremely close conformity with the balls. No retainer is now used, but may yet be introduced because of ball-to-ball scoring which, however, has not caused any failures. The race sections are cut to a minimum for space and weight saving, but introduce serious production problems in maintaining tolerances and roundness. Also large race distortions occur under the heavy loads. Although both inner and outer rings are loosely fitted for assembly, thrust load expands the outer and contracts the inner rings to provide tight radial support. Further-



Has pressure for other war production delayed your getting those new Magnesium assignments under way? American Magnesium Corporation's Jobbing Division may be able to help you by taking on part of that work.

Fabricating is the Job Shop's specialty. The men here understand the manufacturing possibilities of Mazlo Magnesium Alloys. They're expert at forming and joining Magnesium assemblies. By setting up this work here on a production-line basis, they solve the very problems that may be bothering you.

Pictured above, you see Magnesium oil tanks for aircraft being assembled in the American Magnesium Job Shop. Mazlo Magnesium products contribute the light weight so necessary in airplane construction. The Jobbing Division has the know-how which speeds this production, so vital to the war effort.

If you have some problem on which this Magnesium fabricating experience will serve as a guide, we'll gladly talk with you about it. Or we'll see if we can fit it into the Job Shop's schedule. Aluminum Company of America *(Sales Agent for Mazlo Magnesium Products)* 1703 Gulf Building, Pittsburgh, Pennsylvania.

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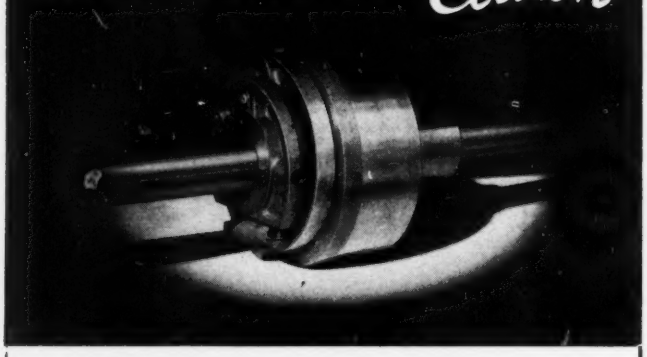

Wherever extremely accurate control of intermittent machine operation is essential the Hilliard Single Revolution Clutch is unequalled. Its accuracy has won for it the acceptance of Industry for cutting, punching and packaging operations.

★ WRITE TO-DAY!
For information that will help you to adapt this clutch to your needs.

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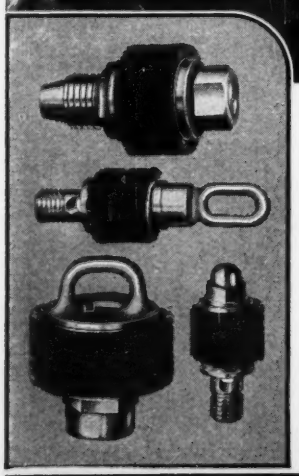

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Fullergript Bore Cleaning Brushes meet Army specifications, and are used for cleaning guns from 37 mm. up to and including 205 mm. Naval Ordnance Gun Brushes are also made by us for One Pounder up to 6" Navy Guns.
We act as prime contractors or can subcontract brushes or parts to manufacturers of carriages and accessories.

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more this distortion is not uniform. The rings tend to become conical and polygonal. Race sections have been recently redesigned with an offset (*Fig.* 4) to keep the bores and outside diameters more nearly cylindrical under the load.

Fig. 4 also shows a preload bearing. By pulling the stacked bearings tightly initially against the preload bearing, all looseness is eliminated, providing smoother throttling conditions and also less deflections under load for better location of gears on the propeller blade. The preload bearing also provides inner radial support even when the operating thrust of the blade removes all the preload from the bearing.

Load variations and vibration produce considerable working or fidgeting between the bearings and the blade and also on the outside diameters. Severe galling results, sometimes reaching the stage where it might be called gouging. This has been alleviated by slightly looser fits and even more by special plating both on the blade and on the bearings, usually a hard material on the blade and a softer thin plating on the bearing bores. So called antigalling lubricants or compounds have proved of little help as might be expected under high unit pressures. Likewise rust proofing or treating the surfaces has not so far been useful as the galling is not a true "false brinelling" or "fretting corrosion".

How False Brinelling Is Overcome

"False brinelling" refers more exactly to what happens at the ball-race contact under the continuous slight oscillations of an automatic propeller. The most effective antidotes are first adequate bearing size to keep the unit pressures down and second complete submersion of the bearings in oil or special greases. In any case the large centrifugal force packs the lubricant into the bearings quite tightly and an effective seal is required. A new concept of "brinelling" or "nonbrinell" capacity has been developed in selecting the bearings for the occasional large momentary loads, i.e., the maximum load that can be applied without permanent surface deformation. A surprisingly large step exists between the first permanent surface impression visable under a small magnification and the first measurable depression.

This brinelling capacity, however, is not the only control on bearing size since such loads cannot be employed often and since the automatic propeller has eliminated large loads from momentary overspeeds as in a dive. The other control of size is resistance to "false brinelling" under normal loads and the brinelling capacity serves only as a method of comparison.

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3. Almen, J. O.—"Lubrication and False Brinelling of Ball and Roller Bearings", *Mechanical Engineering*, June 1937, Pages 415-422. Also discussion by the author, *Mechanical Engineering*, September, 1937, Pages 703-704.
4. N. A. C. A. Report 707.
5. Barish, Thomas—"Preloaded Antifriction Bearings", MACHINE DESIGN, October, 1931, Pages 36-40. This article describes method of obtaining load division.

Raise the operating standards of your machines—bring Victory nearer; redesign to get in more Timken Bearings. You also will find this a big advantage in meeting post-war competition.

Typical of the urgent need for doing things quicker and better these days and of the value of Timken Tapered Roller Bearings in accomplishing them is this giant cylinder honing machine.

It was designed and built by the Cooper-Bessemer Corporation for finishing the cylinders of Cooper-Bessemer gas and diesel engines and compressors.

Cylinders up to 30″ in diameter can be precision honed on this machine which has a stroke of from 6″ to 90″; infinitely variable spindle speeds from 12 to 90 R.P.M.; and spindle reciprocation from 0 to 60 feet per minute (infinitely variable).

Power is supplied by 6 electric motors as follows: main drive, 50 H.P. variable speed; hydraulic pump, 15 H.P.; hone guide, 1 H.P.; coolant pump motor, ¾ H.P.; lubricating oil pump motor, ½ H.P.; hydraulic fluid volume control motor, ½ H.P.

Timken Bearings are used in the gear box, right angle drive, ram assembly and table wheel mounting.

The machine is 32 feet high and weighs 60,000 lbs. Machine table capacity 25,000 lbs.

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TAPERED ROLLER BEARINGS

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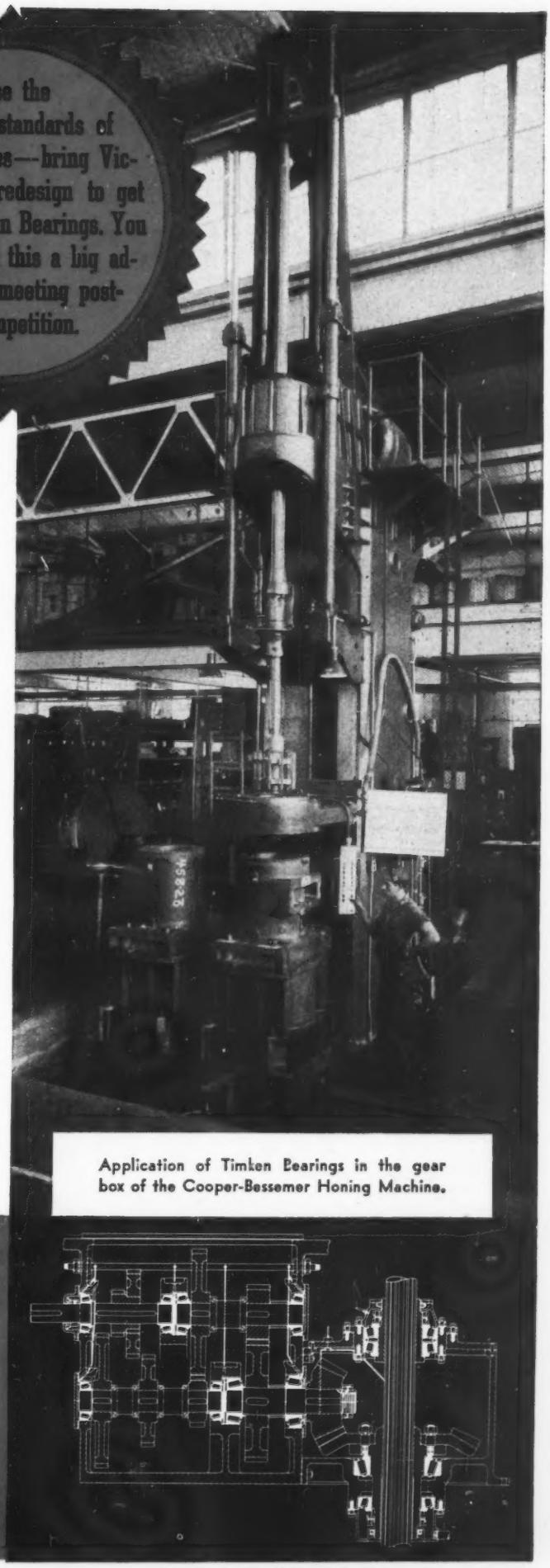

Application of Timken Bearings in the gear box of the Cooper-Bessemer Honing Machine.

HELP ASSURE VICTORY

Buy War Bonds. Conserve Rubber. Eliminate Unnecessary Travel. Use the Telephone Only When Important. Salvage All Scrap and Waste Material.

All Timken Bearing production now goes into fighting machines. However, the Timken Bearings in your motor vehicles or industrial machines will see you through the emergency—and beyond it—if you make sure they are lubricated and inspected regularly.

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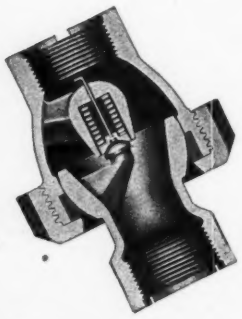
STREAMLINED FLEXIBLE BALL JOINTS

STEAM — AIR — GAS OIL AND OTHER FLUIDS

Stainless Steel Spring shrouded for protection against fluids, corrosion and erosion.

Spring pressure exactly centered against ball provides equal pressure of ball against gasket seat adjustment is automatic.



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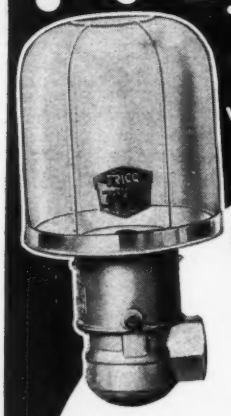

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BUSINESS AND SALES BRIEFS

PREVIOUSLY assistant manager of the hydraulic department in charge of centrifugal pump sales and engineering, H. P. Binder has been made manager of the centrifugal pump department of Allis-Chalmers Mfg. Co., Milwaukee. He joined the company's student training course in 1911, and since 1919 has been connected with the hydraulic department.

♦

A group of eastern plastic firms has been certified by the War Production Board as an association, to be known as Plastic War Production association. The purpose of the new organization is to pool the engineering, research and manufacturing facilities of the members for the benefit of the various government branches placing war contracts. Facilities of the membership are varied, including presses, machinery and finishing equipment capable of production of all types of parts, etc., necessary for the war effort. One of the most important functions of the association will be to develop through research and experimentation and in close cooperation with the procurement offices of the Armed Forces, new applications of plastics which will result in substantial and necessary conservation of vital metals. The association is located at 122 East Forty-second street, New York.

♦

After spending two months in the research laboratories of the Plastics Industries Technical Institute in Los Angeles, J. Earl Simonds is now back in New York where he will handle the consulting and research contacts for the institute in the East and Middle West. He has been appointed assistant technical director of the Eastern Division of the Institute.

♦

According to a recent announcement by W. H. Henry of the motor division, industrial department General Electric Co., Schenectady, N. Y., J. L. Townsend has been appointed assistant manager of sales, fractional-horsepower motor section of the motor division. Mr. Townsend joined the company as a student engineer and a year later was transferred to the fractional-horsepower motor sales department. After various sales positions, he was reassigned to this department at the Fort Wayne Works in 1937.

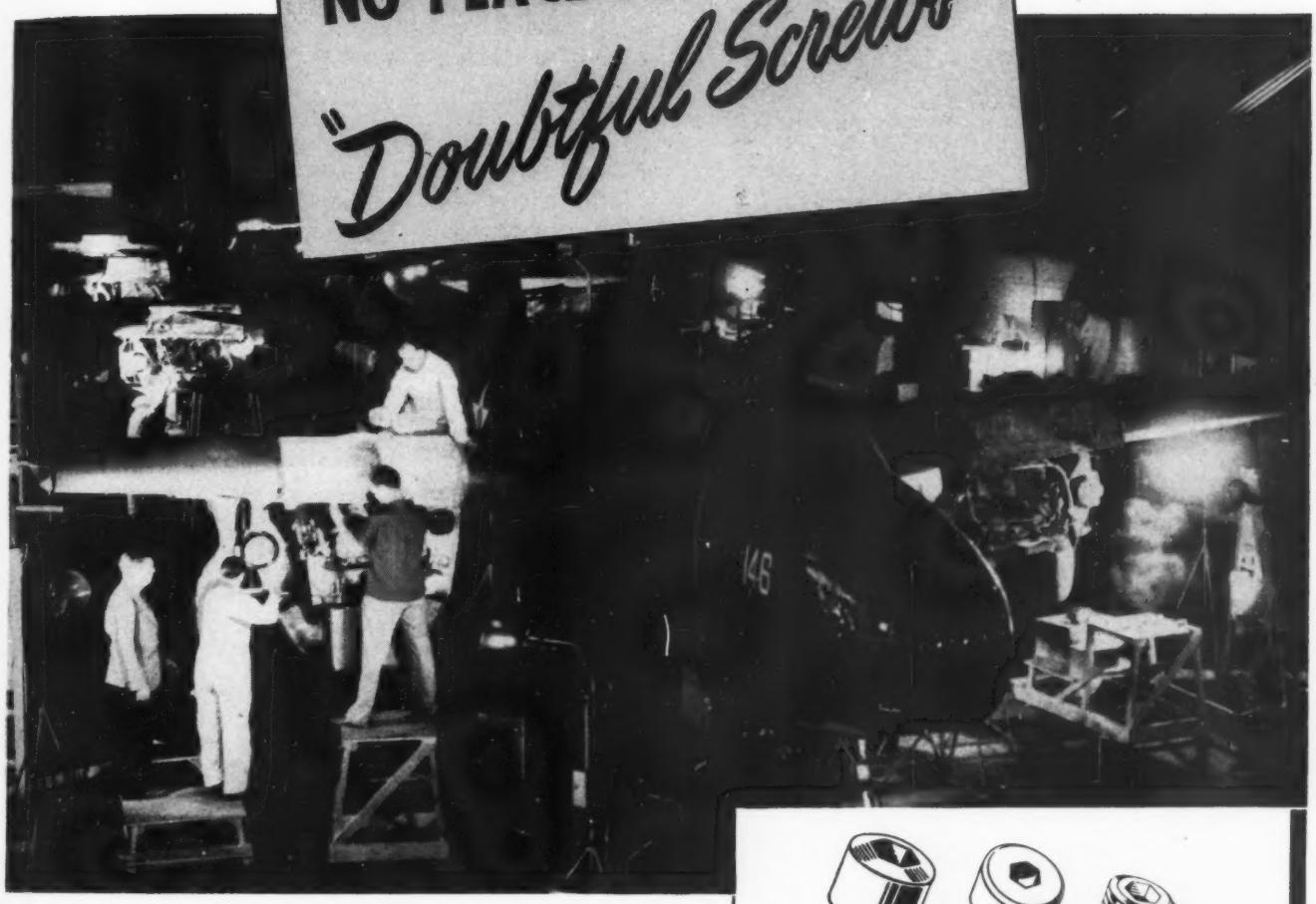
♦

Located at the Chicago office—520 North Michigan avenue—of the Lord Mfg. Co., Gordon E. Graber is now a field engineer. He formerly was with American Seating Co. George Harrington, who was field engineer for the company previously, is now a lieutenant in the navy and is stationed at the U. S. Navy Bureau of Aeronautics, Washington, D. C.

♦

Appointment of Earl Wesselhoff as manager of the Boston office of Morse Chain Co., Ithaca, N. Y., has been

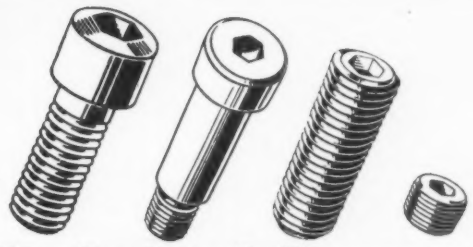
NO PLACE FOR "Doubtful Screws"



-In Fighting Equipment that Must "Take It"!

Allies and enemies alike express amazement over the amount of punishment that American planes and combat cars will take. American engineers and production men have disproved any idea that they couldn't build fast and build well, too. While they've put on night shifts . . . speeded-up in a thousand ways . . . they've refused to take chances with "doubtful materials". And, in their insistence that every integral part must conform to rigid standards, lies the reason why Parker-Kalon Quality-Controlled Socket Screws are "on the preferred list" of so many makers of planes and engines, combat cars and trucks.

P-K Socket Screws have the extra dependability that severe service requires. "Doubtful screws" . . . screws that *look* all right but some of which fail to *work* right . . . are eliminated by the unequalled quality-control routine of the Parker-Kalon Laboratory. This assurance covers all physical and mechanical characteristics . . . yet P-K Screws cost no more. Parker-Kalon Corp., 192-200 Varick St., New York.



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SOCKET SCREWS

Give the Green Light to War Assemblies

NEW!

MODEL SP400

BRADY-PENROD

Self-Priming Centrifugal Coolant Pumps

"They Pump Air"

Through clever application of the fundamental principle of Patent No. 2,164,869, these pumps are simple in design, thoroughly dependable and instantly self-priming on normal suction lifts encountered with machine tools. Model SP400 is sturdily built, with all the superior BRADY-PENROD features, to handle abrasives and steel chips. Easily installed on present machines or quickly adapted to new machines.

Send for FREE Bulletin

BRADY-PENROD, INC.

1212 W. SECOND STREET MUNCIE, INDIANA

Air cylinders and solenoid valves on BODINE dial type automatic drilling and reaming machines operate on air that is cleaned, controlled, and lubricated with Norgren Units. Also note Norgren couplings.

NORGREN *Lubro-Control* UNITS • • •

. . . clean the air, regulate pressures, and create a *fog of oil* in the air stream —to lubricate every moving part of air actuated mechanisms against wear in use, against corrosion when idle.

Many combinations and sizes to meet your own requirements.

Catalog 400 **C. A. NORGREN CO.** DENVER COLORADO

announced. He replaces C. L. Pratt Jr., resigned. Mr. Wesselhoff's association with the company started twenty-two years ago as automotive timing chain drive engineer at the Detroit plant. Since then he has served in several capacities including that of the dual position of chief engineer and sales director of the company's indexing and freewheeling clutch lines.

♦

With headquarters in Cleveland, E. O. Callander has been appointed sales representative for General Electric wiring materials in Ohio. He has been associated with General Electric Supply Corp., Toledo, O., for five years.

♦

Copperweld Steel Co., Warren, O., has appointed A. H. Philpot, metallurgical engineer, to manage its Washington district office. He will be active in the sale and application of the company's alloy steels.

♦

Formerly known as the Tight Closure Co., this organization is now operating under the name of Taylor Mfg. Co., Plastics Division, 3056 West Meinecke avenue, Milwaukee.

MEETINGS AND EXPOSITIONS

January 8—

Society of the Chemical Industry. Joint meeting with American Chemical Society, American Institute of Chemical Engineers, Electrochemical Society and Societe de Chimie Industrielle to be held in New York. C. S. Kimball, 305 Washington street, Brooklyn, N. Y., is secretary.

January 11-15—

Society of Automotive Engineers. War production engineering meeting and display to be held at the Book-Cadillac hotel, Detroit. John A. C. Warner, 29 West Thirty-ninth street, New York, is secretary and general manager.

January 20-21—

American Society of Civil Engineers. Annual meeting to be held at the Engineering Societies building, 29 West Thirty-ninth street, New York. George T. Seabury, same address, is secretary.

January 25-27—

American Society of Heating and Ventilating Engineers. Annual meeting to be held at Hotel Gibson, Cincinnati. A. V. Hutchinson, 51 Madison avenue, New York, is secretary.

January 25-29—

American Institute of Electrical Engineers. National technical meeting to be held at the Engineering Societies building, New York. H. H. Henline, 33 West Thirty-ninth street, New York, is secretary.

April 20-23—

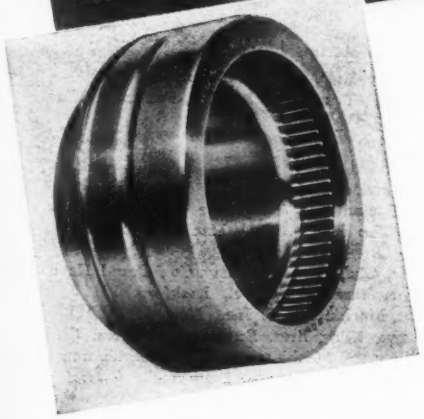
National Electrical Manufacturers' association. Spring meeting to be held at the Palmer House, Chicago. W. J. Donald, 155 East Forty-fourth street, New York, is managing director.

April 28-30—

American Foundrymen's association. Forty-seventh annual meeting to be held at Hotels Jefferson and Statler. St. Louis. R. E. Kennedy, 222 West Adams street. Chicago, is secretary.

"ALL ROADS LEAD TO ROME"

...and Berlin



GALION and RBC

are teamed up for the job

Wherever they are, all roads, air base runways and landing fields are built with one purpose—to smooth the way for speedy transport of men and materials, for the safe takeoff and landing of planes—all of which are destined to play a part in the complete capitulation of the Axis. Galion 3-wheel, portable and tandem Rollers are equipped for this heavy duty with RBC Roller Bearings whose anti-friction and high load carrying characteristics provide for smooth operation, long life and minimum maintenance.

ROLLER BEARING CO. of AMERICA

TRENTON . . . . NEW JERSEY

G-E NEON GLOW LAMPS

For use as Pilots and Indicators

GENERAL ELECTRIC Neon Glow Lamps are ideal as pilots and indicators in industrial war plants because they require little power, can operate on standby battery or generator service, and stand up under shock or vibration. They produce a distinctive orange-red light and have a useful life of about 3000 hours.

They are used as pilot lights to show location of switches, sprinkler valves, alarm boxes, emergency doors and exits, and as indicators for fuses and for machines with small quiet motors which may run unnoticed. They may also be used as test lamps for electrical circuits, for synchronizing any two or more moving machines and checking speed.

Maybe some vital equipment you make can be made more efficient with the help of glow lamps. Your electrical wholesaler can supply the complete line. For a free folder showing many uses, write Dept. MD1, at the address below.

TYPE S-14 G-E Glow Lamp is available in 3, 2½, and 2-watt sizes.

NELA SPECIALTY DIVISION, LAMP DEPT.
GENERAL ELECTRIC
410 Eighth Street, Hoboken, N. J.

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#4

We have increased the number of shapes now available without die or tool charges, and call it "Shape Book #4". Designers, engineers, experimenters should have a copy. These shapes are economical—no tool costs to be absorbed or paid.

Now being mailed to our lists. If you do not receive a copy, Request One.

THE COMMERCIAL SHEARING AND STAMPING COMPANY.
YOUNGSTOWN · OHIO · U.S.A.

NEW MACHINES—

And the Companies Behind Them

(*For illustrations of other outstanding machinery, see Pages 80-81*)

Armament

Bomb-marking machine, James H. Matthews & Co., Pittsburgh.
Air raid siren, Breuer Electric Mfg. Co., Chicago.
Airport fire truck, Cardox Corp., Chicago.

Chemical

Kneading type mixer, Paul O. Abbe Inc., Little Falls, N. J.

Dairy

Portable milking machine, Ben H. Anderson Mfg. Co., Madison, Wis.

Finishing

General purpose superfinishing machine, International Machine Tool Corp., Elkhart, Ind.
Heavy-duty precision cleaning machine, L & R Mfg. Co., Newark, N. J.
Paint spray booth, Aqua-Restor Div., Mayer Mfg. Corp., Brooklyn.
Automatic air-coating unit, Paasche Airbrush Co., Chicago.
*Heavy-duty polisher, The Hisey Wolf Machine Co., Cincinnati.

Food

Dehydrating spray drying system, Drying & Concentrating Co., Chicago.
Food dehydrator, Bridges-Wilson Corp., Arlington, Mass.

Heat Treating

Taper annealing machine, Morrison Engineering Co., Cleveland.
Annealing furnaces with special quenching and drying mechanism, Salem Engineering Co., Salem, O.
Forced convection heat-treating furnace, Lindberg Engineering Co., Chicago.
Salt bath furnace, Upton Electric Furnace Div., Detroit.

Industrial

Exhauster and blower, Chelsea Fan & Blower Co. Inc., Irvington, N. J.
Self-contained dust collector, Aget-Detroit Manufacturing, Detroit.
Portable coolant system, Gray-Mills Co., Chicago.

Instruments

*Dynograph balancer, R. B. Annis Co., Indianapolis, Ind.
*Hydraulic spark plug testing unit, Dennison Engineering Co., Columbus, O.
Dynetric balancing machine, Gisholt Machine Co., Madison, Wis.

Materials Handling

Industrial lift trucks, Lewis-Shepard Co., Watertown, Mass.
Power turret trucks, Nutting Truck & Caster Co., Faribault, Minn.

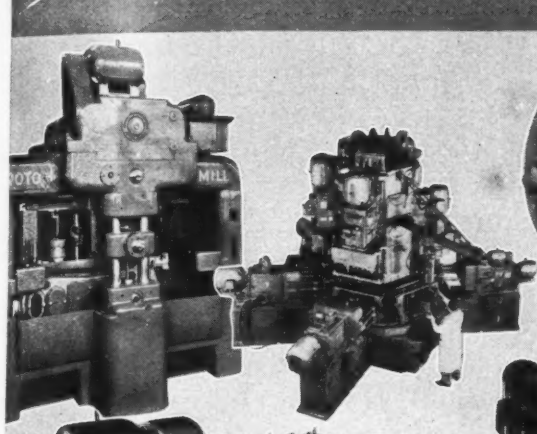
Metalworking

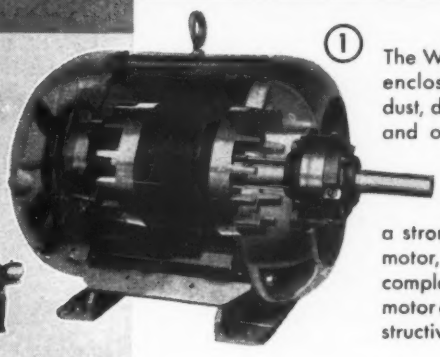
Power hack saw, Sales Service & Mfg. Co., St. Paul.
Metal-cutting machine, Racine Tool & Machine Co., Racine, Wis.
Ram-type turret lathe, The International Machine Tool Corp., Foster Div., Elkhart, Ind.
Abrasive cut-off machine, Challenge Machinery Co., Grand Haven, Mich.
Vertical honing machine, Barnes Drill Co., Rockford, Ill.
Vertical slotter, Douglas Machinery Co. Inc., New York.
Down-stroke friction saws, Kling Bros. Engineering Works, Chicago.
Belt backstand idler, Hammond Machinery Builders Inc., Kalamazoo, Mich.
*Plain miller, Douglas Machinery Co. Inc., New York.
*Broach sharpening machine, Colonial Broach Co., Detroit.
*Metal-cutting band saw, Wells Mfg. Co., Three Rivers, Mich.

Welding

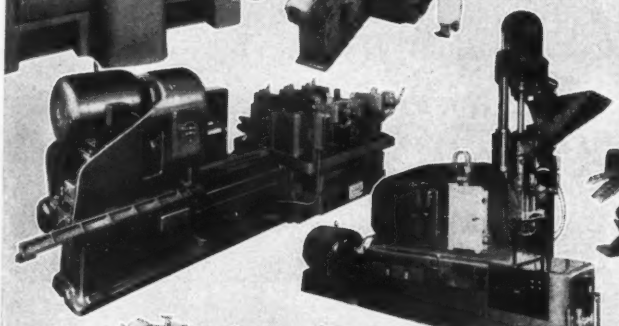
Manually-operated welder, Glenn Roberts Co., Oakland, Calif.
Arc welders, Trindl Products Ltd., Chicago.
Radial spot welder, Sciaky Bros., Chicago.
*Electric welding machine, Hampton Electric Mfg. Co., Pittsburgh.
*Welding transformer, General Electric Co., Schenectady, N. Y.

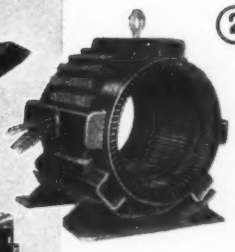
WAGNER CP MOTORS
were selected for these machines because:



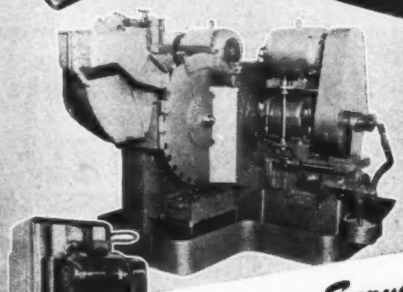


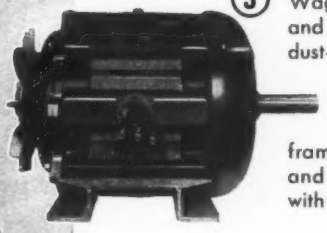
① The Wagner CP motor is totally-enclosed against entrance of dust, dirt, filings, fumes, moisture and other troublesome matter. This is accomplished by means of two frames, an outer frame which guides a strong cooling draft over the motor, and an inner frame which completely seals vital parts of the motor against the entrance of destructive or injurious substances.



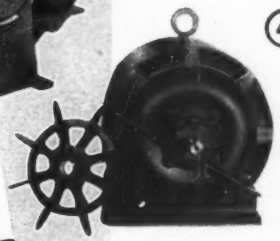


② Typical Wagner CP stator — strong, sturdy, rigid — built to meet the exacting strains met in modern industry. Stator is deeply grooved to increase radiation surface. The winding is completely taped well into the slots and all phase coils are insulated from each other by varnished muslin phase sheets.





③ Wagner CP motor with fan shield and center shield removed showing dust-tight inner frame. Flexible compound completely seals the lead openings. No dust, fumes, or moisture can enter the inner frame which protects the windings and bearings from actual contact with the cooling air.



④ End view of CP motor with fan shield removed showing air ducts between inner and outer frames. These large air passages surround the entire stator. End-plates are concentrically machined for perfect stator-frame fit. Pipe extension from bearing housing permits lubrication of fan-end bearing without removing the fan shield.

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Today, with production at an all time high, you cannot afford to "take a chance" on motor efficiency. Shutdowns because of motor failure cannot be tolerated. Provide the motor driven machines and equipment you manufacture or use in your plant with the RIGHT Wagner motor.

Wagner's 25 branch offices are manned by trained field engineers, competent to solve your motor application problems. They will gladly consult with you and do everything possible to assure the quickest delivery on motors you need to keep your war production schedule on time.

GET THE COMPLETE STORY ON WAGNER CP MOTORS

Bulletin MU-182 gives detailed information on the design and construction of Wagner CP motors. Write for your copy today.

M42-36

Wagner Electric Corporation

6400 Plymouth Avenue, Saint Louis, Mo., U.S.A.

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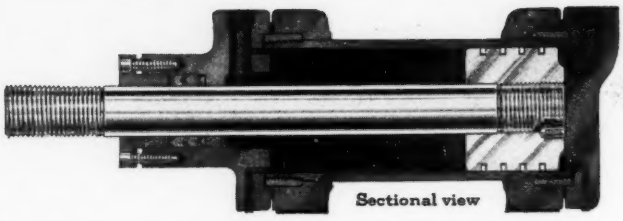
Two Reasons for the use of HANNIFIN Hydraulic Cylinders



Sectional view

Exclusive no-tie-rod design, with universal end caps, makes a simpler, stronger hydraulic cylinder, easier to apply to any hydraulic power use.

Precision construction with mirror finish honing produces a straight, round, perfectly finished cylinder bore, for high efficiency piston seal with minimum fluid slip and maximum power.

Whether you need unusually large cylinders, or small sizes, Hannifin precision construction can help you make the most of hydraulic power advantages. Built in seven standard mounting types, with or without cushion. All sizes, any length of stroke, for working pressures up to 1000 and 1500 psi. Special cylinders built to order. Write for Bulletin 35-MD with complete specifications.

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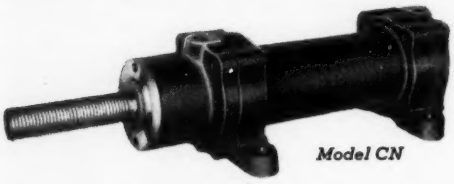
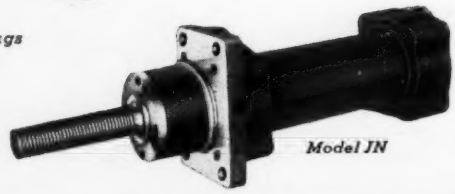


Model CN

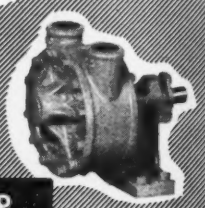
Other Mountings Available



Model JN

HANNIFIN
HYDRAULIC CYLINDERS

TUTHILL



THE COOLANT PUMP that laughs at chips and grit

There are good reasons why the Tuthill Model M Coolant Pump is outstanding in wartime production. Compactly built, this positive displacement internal-gear rotary pump is designed with an exclusive safety feature that assures long, dependable, uninterrupted service.

Model M has a built-in, automatic by-pass which permits small chips and similar particles to pass through the pump without serious injury to working parts, and compensates for wear.

Six sizes from 1 to 50 g.p.m. Available in stripped form for direct incorporation into the design of the machine, to save space and material.

Write for complete catalog describing these and other dependable pumps for production machinery and scores of wartime applications

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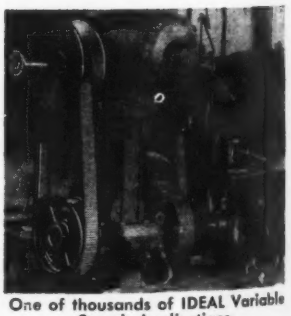
DO MACHINES YOU DESIGN MEET WAR PRODUCTION'S

VARIABLE SPEED REQUIREMENTS?

IDEAL VARIABLE *Speed*

Without changing their basic design, you can add IDEAL Variable Speed to machines you build, and give them that wider range of production control, so much in demand today. Easy to install; mounts directly to motor shaft.



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GAIN ALL THESE ADVANTAGES

● Full rated H.P. regardless of load conditions. ● Long belt life. ● Minimum maintenance. ● Low cost. ● Available in V-Belt and wide V-Belt types. Sizes up to 8 H.P.

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52-page book, gives all the information about IDEAL Variable Speed; how it works, how installed, dimensions and ratings, application photos, speed charts, etc.

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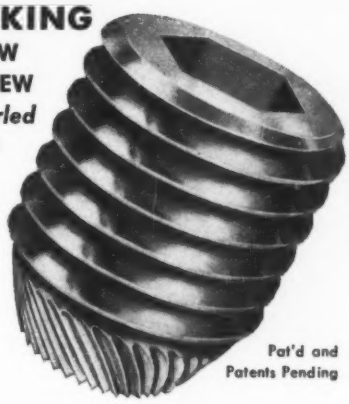
KNURLING OF UNBRAKO SOCKET SCREWS Gives You THESE EXCLUSIVE ADVANTAGES

KNURLED SOCKET HEAD CAP SCREW

SELF-LOCKING HOLLOW SET SCREW *with Knurled Points*



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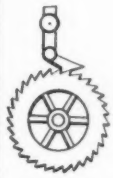
KNURLING SAVES TIME AND LABOR

By preventing slipping, so the fingers can be used to best advantage. The firm grip enables mechanics to turn screws with speed and accuracy.

KNURLING PERMITS LOCKING

Showing locked-in screw and locking tool.

After countersinking, a few smart blows with a special locking-tool, having a circular edge and pilot in center, displaces enough metal to engage knurls and lock screw. Screw can be backed out and used over and over.



KNURLED POINTS LOCK SCREW

The knurling is so cleverly done that—on the principle of a ratchet—the point makes no resistance when screw is *tightened*, but as soon as vibration tries to loosen it, the knurls "dig in" and positively prevent it. Screws can be taken out with a key and used repeatedly.

Plus THESE ADVANTAGES

UNBELIEVABLE STRENGTH—"UNBRAKO" Screws register an ultimate tensile strength of 289,200 lbs. per sq. inch.

METAL SAVING—The great strength of "UNBRAKO" Screws permit the use of smaller and fewer screws. Because the key operates within the socket, "UNBRAKO" Screws can be used in the closest of quarters so designs can be more compact and lighter.

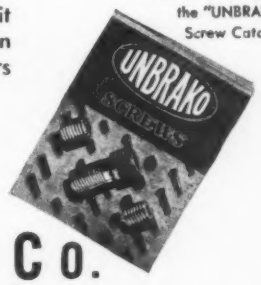
CLOSE TOLERANCE—"UNBRAKO" Screws are precision made.

DELIVERIES—better than average.

SIZES—from No. 4 to 1½" diameter.

The KNURLING of Socket Screws originated with "Unbrako" years ago.

Send for a copy of the "UNBRAKO" Screw Catalog.



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LOGANSPORT MACHINE, Incorporated

911 Payson Road Logansport, Ind.

HELPFUL LITERATURE

for DESIGN EXECUTIVES

1. Electronic Tubes

General Electric Co.—4-page illustrated, "Quick Selection Chart of Electronic Tubes for Industry," gives comprehensive technical data on applications and types of tubes. Tabular form makes it possible to select correct tube for any particular requirement.

2. Plywood Handbook

Douglas Fir Plywood Association — "Handbook of Industrial Uses for Plywood" is designed to record for future use the industrial applications of plywood as they are developed by the war program. Contents consist of pamphlets, reprints from magazines and bulletins. Additional releases will be supplied and they can be placed in this loose-leaf type binder.

3. Seamless Tubes

Babcock & Wilcox Tube Co.—24-page illustrated condensed catalog No. TB-319 covers seamless steel boiler tubes, alloy tubes and pipe for refinery and process industries, stainless steel tube and pipe, and seamless steel mechanical tubing Manufacturing processes and applications are described.

4. Roller Bearings

S K F Industries, Inc.—88-page illustrated bulletin, "Steel Mill Data for Calculation and Design," is reference volume which contains formulas, designs, data tabulations and other information. Subjects covered include bearing applications for auxiliary equipment, cranes, drives and roll-neck bearing design, maintenance and lubrication.

5. Internal Wrenching Bolts

Holo-Krome Screw Corp.—16-page illustrated bulletin, "N.A.S. Standards—Internal Wrenching Bolts," lists standards which were developed and approved by the National Aircraft Standards committee. Permission was given to this company by the committee to publish these standards. Data are of particular value to aircraft designers and engineers.

6. Motor Selector

Allis-Chalmers Manufacturing Co.—Slide-rule type "Motor Finder" is designed to help motor users fill their wartime motor needs with least possible delay, as well as conform to recent WPB recommendations. Simple settings of rotating discs permit selection of various types of squirrel-cage motors. Features and characteristics of each motor type are readily determined.

7. Calendar

Dayton Rogers Manufacturing Co.—Large size wall calendar for 1943 also contains decimal equivalent chart, with equivalents given to six figures on dimensions from 1/64 to 1 inch, in increments of 1/64 inch. Also available is smaller calendar, with chart printed in two colors.

8. Electrical Relays

C. P. Clare & Co.—44-page illustrated bulletin, "Relay Data", has been compiled to give relay user understanding of styles and to assist in proper application of relays. In addition to descriptions of various types of relays, complete data are included on available coil arrangements.

9. Printing Machines

Charles Bruning Co.—12-page illustrated bulletin, "Index to New Printing and Developing Advantages," lists and describes printers and developers of all sizes and capacities for reproducing prints from tracings. Features of various models are outlined and specifications given.

10. Switchboard Instruments

Roller-Smith Co.—12-page illustrated catalog No. 4220 gives specifications and other information on line of switchboard instruments, including direct current ammeters and voltmeters, alternating current ammeters, voltmeters, wattmeters, frequency and power factor meters, synchroscopes and similar instruments.

11. Air Filters

American Air Filter Co.—8-page illustrated bulletin No. 120D is descriptive of air filters for application to air compressors, diesel and gas engines. Construction features, capacity tables, installation data and other pertinent information are given.

12. Corrosion Preventives

United States Stoneware Co.—12-page illustrated booklet, "New Horizons," gives information on various materials which have been developed for preventing corrosion of machines and equipment. Plastics, lead coatings, alloys, ceramics and refractories of various types are described and typical applications outlined.

13. Bronze Welding Rod

Ampco Metal, Inc.—16-page illustrated "Ampco-Trode" bulletin describes welding technique and application of coated aluminum bronze welding rod which is suitable for metallic arc, carbon arc and oxyacetylene welding. In addition to presenting general welding instructions, drawings of methods, photographs of typical beads and X-ray views of welds are included.

14. Motor Maintenance

Century Electric Co.—4-page illustrated bulletin No. 21-171 describes installation, care and adjustment of fractional horsepower direct current motors. Points to check before starting motor, as well as trouble-shooting suggestions are given.

15. Oil Cooling Equipment

Refrigeration Economics Co.—4-page illustrated bulletin No. H-42 discusses oil and liquid cooling units for use in conjunction with machine tools producing parts for war machines. Coolant oils may be cooled to any required temperatures to obtain maximum production. Refrigerating shell and tube, shell and fin coil, and evaporative condensers are described and specifications given.

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HELPFUL LITERATURE

16. Mounted Wheels

Chicago Wheel & Manufacturing Co.—64-page illustrated bulletin No. F980 is selection guide for mounted wheels, small portable grinders, drill presses, steel cutters, saws, polishing wheels, brushes and other abrasive wheels. All styles of mounted wheels are shown full size. Complete specifications are given on "Handee" motor driven portable hand tools.

17. Plastic Manual

E. I. duPont de Nemours & Co., Plastics department—134-page "Lucite Aircraft Manual" discusses forms, shapes and sizes of this methyl methacrylate resin. Various general methods of fabrication on which satisfactory results have been obtained in industry are described. Sketches, tables and photographs amplify instructions.

18. Drafting Ink

Louis Melind Co.—Illustrated leaflet announces new line of drafting ink under trade name of "Justrite". Ink is claimed to flow freely and will not cake. It is of an opaque black color. Free samples available upon request.

19. Engineer's Calendar

Frederick Post Co.—Containing 52 weekly sheets, this 1943 calendar has large black numerals which can be read easily from any part of drafting room. Calendar measures 15¾ x 24½ inches. Section of technical data contains charts on wire and sheet metal gages, screw threads and other commonly used information.

20. Hydraulic Pumps

Hydra-Motive, Inc.—Illustrated bulletin No. Hy-2 describes infinitely variable delivery hydraulic vane pumps with standard mounting which permits their adaptation to all types of equipment. Shown is dual vane arrangement which is claimed to reduce wear, eliminate overheating and permit long period operation at excessive pressures.

21. Air Cylinders

Logansport Machine Inc.—4-page illustrated monthly publication, "Logan Leads", Vol. 2, No. 1 presents information on complete line of air-hydraulic power devices, chucks, cylinders, valves and fittings. This issue describes standard types of non-rotating air cylinders.

22. Forged Steel Fittings

Watson-Stillman Co.—44-page illustrated bulletin No. A-3 describes 166 different types of forged steel fittings and stresses advantages of these fittings in high pressure, high temperature service. Full data are given on all types in various alloys. Engineering section contains data of interest to users of fittings and piping.

23. Selective Hardening

United Chromium, Inc.—6-page illustrated leaflet No. 27 describes "Unichrome Alkaline Copper Plating" process and explains why its characteristics are of value in selective hardening and deep drawing of steel parts. Also covered are stripping baths which remove copper coatings without affecting steel base metal.

24. Rheostats

DeJur-Amsco Corp.—Illustrated folder on potentiometers and rheostats shows various types of these units and gives complete specifications. Design and application data are also included, and features are covered.

25. Steel Coloring

Du-Lite Chemical Corp.—8-page illustrated bulletin on "Steel Coloring Processes" explains methods by which an attractive, durable and rust resisting finish can be applied to steel. Applications of this process to finishing parts for war equipment and ordnance purposes are outlined and pictured.

26. Pipe, Tubes & Fittings

National Carbon Co.,—8-page illustrated catalog section No. M-8800A covers "National" and "Karbate" carbon and graphite pipe, tubes and fittings used for handling of corrosive liquids and gases and in construction of heat exchangers. Specifications and diagrams showing construction details are included.

27. Metal Fabrication

L. O. Koven & Bro., Inc.—16-page illustrated bulletin, "Men and Machines for War Work," outlines facilities of this concern, and lists skilled personnel and equipment which are available for metal fabricating for both prime and subcontract war production. Also shown are typical equipment and fabrications produced for industrial and armament use.

28. Wiring Devices

Aircraft Marine Products Inc.—32-page illustrated catalog, "Solderless Wiring Devices," presents complete data on terminals, cable lugs, bonding jumpers, connectors, wiring plugs and lighting contracts. Over 300 connecting devices which require no solder are described. These connectors are approved for aircraft, marine communications and commercial use.

29. Steel Shapes

Commercial Shearing & Stamping Co.—20-page illustrated booklet No. 4 describes number of standard steel shapes. Listed are circular shapes for tank heads, furnace heads, steel tunnel lining, fabricated and welded parts, stampings, hydraulic equipment and steel pallets for concrete block industry. Several of these circular shapes are shown.

30. Controls

Allen-Bradley Co.—8-page illustrated bulletin No. 836 covers line of pressure and temperature controls used for pilot duty application, for operation of contactors or for direct control of small alternating and direct current motors. Controls are operated by seamless metal bellows which operate snap-action precision switch with straight line motion.

31. Mercury Contacts

General Electric Co., Nela Specialty division—8-page illustrated folder. No. NS254 describes "G-E Kon-nec-tors" of mercury-to-mercury contact type. They are suitable for general use at currents up to 25 amperes. These switches consist of simple, single throw, single pole contacts with companion types for double throw, two of which are curved to provide neutral or off position.

32. Vibration Eliminators

B. F. Goodrich Co.—12-page illustrated catalog section No. 7900 discusses use of "Vibro-Insulators" to absorb vibrations and reduce noise. They are rubber springs which are designed to carry load in shear. Catalog shows specifications, methods of mounting and applications of springs.

33. Electric Motors

Westinghouse Electric & Manufacturing Co.—20-page illustrated booklet No. B-3188 explains program entitled "Calling All Horsepower" designed to save critical war materials and to get maximum production out of every motor. Six wartime application recommendations are listed and discussed. Accompanying charts and illustrations give specific information on pounds of war material which can be saved by each method.

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